The AUTOMATIC ELECTRIC Technical Journal

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October, 1949

Issued by

AUTOMATIC ELECTRIC COMPANY
Chicago, U. S. A.
and affiliated companies

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IMRE MOLNAR received his first experience in telephone work in the installation of major projects in Europe during the period 1921-25. After graduating in Communication Engineering (Berlin, 1930), he became associated with the Automatic Electric Group; he was first engaged in circuit design, transmission engineering and installation, and served also as resident engineer in several foreign countries. Between 1937 and 1943 he was employed in the Engineering Department of Automatic Electric Company, Chicago, as a circuit design specialist. Since 1943, in his present position as Project Engineer, he has been concerned with general developments in the Automatic Electric Laboratories. Mr. Molnar has been responsible for a number of major advances in the electrical communications field. He is a senior member of the Institute of Radio Engineers.

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The AUTOMATIC ELECTRIC TECHNICAL JOURNAL

A Magazine Devoted to Progress in Communication Engineering

Issued By

AUTOMATIC ELECTRIC COMPANY

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Address all communications to: 1033 W. Van Buren Street, Chicago 7, U.S.A.

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H. E. CLAPHAM, *Editor*

October, 1949 — Price: 50 cents per copy — Vol. 2, No. 1

PARTIAL CONVERSION TECHNIQUES FOR STROWGER AUTOMATIC EXCHANGES

By N. SALVESEN

***SYNOPSIS:** Conditions requiring partial conversion to automatic—method of interconnection of manual and automatic facilities dependent upon many factors—straightforward trunking methods—call-indicator trunking —cordless "B" positions — multiple of manual and automatic lines—conclusion.*

IT IS a recognized fact that a full realization of the inherent economies and advantages of automatic switching can be effected only when an entire exchange, or exchange area, is converted to full automatic operation. The complete conversion to automatic operation in one step obviously simplifies the technical aspects, and provides the best telephone service to all subscribers.

In multi-office networks, however, it is rarely possible to effect a simultaneous conversion of all offices to automatic operation. It is more often a long-drawn-out process of office-by-office conversion, extending over a period of many years.

In single-office exchange areas, conversion to full automatic operation is most frequently effected in one step. Obviously, this is the most desirable plan of procedure. In some cases, however, there may be economic or technical conditions which preclude full conversion in one step and necessitate a partial conversion, permitting a gradual realization of full automatic service. This is particularly true in cases where the manual board may have many years of useful life which can still be utilized. The automatic switching equipment supplied for such an installation would be used either for additional subscribers' facilities, to provide relief from overload on the manual board by the transfer of lines from manual to automatic operation, or a combination of both.

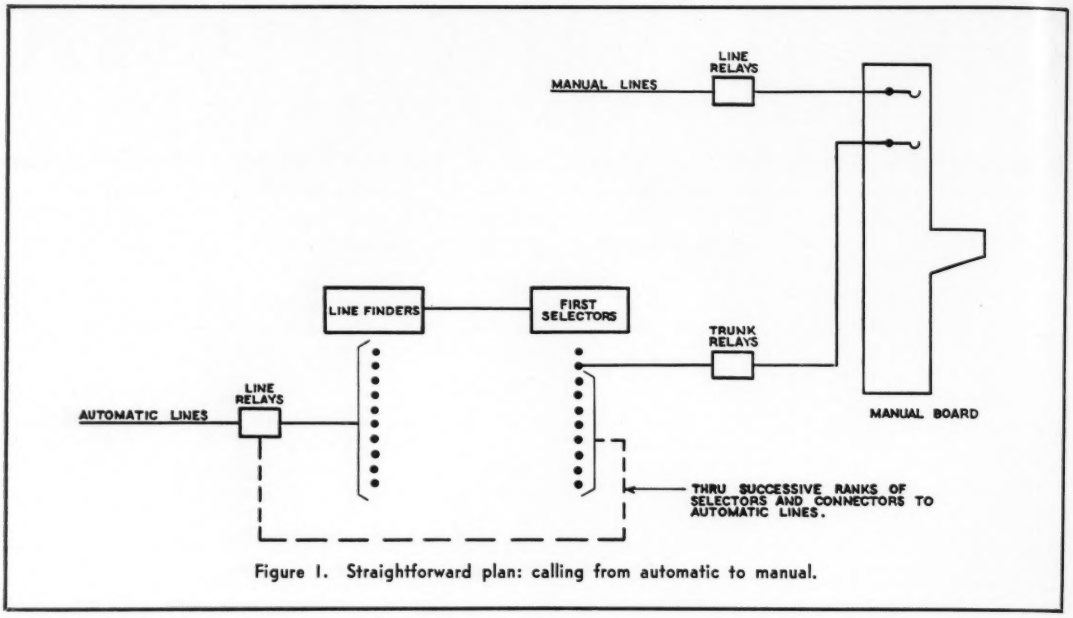


Figure 1. Straightforward plan: calling from automatic to manual.

When a partial conversion to automatic operation is planned, perhaps the predominating problem to be solved is that of interconnection between the automatic and the manual systems. There are several ways in which this interconnection may be accomplished, and the selection of a particular method is to a large extent determined by consideration of the following factors:

(a) Whether the automatic equipment will be located in the same building as the present manual board.

(b) The lapse of time between the initial automatic installation and the final conversion to complete automatic.

(c) Investment value of temporary interconnecting equipment, which will no longer be needed when final conversion is made.

(d) Cost of additional operator effort to complete calls between manual and automatic stations.

(e) Which method of calling between the two systems will be least confusing to subscribers.

Straightforward Trunking

Among the various means which are available for interconnection between automatic and manual systems, perhaps the simplest and least costly are the straightforward methods shown in Figures 1 and 2. These plans are generally used when traffic between the two systems is relatively light, and the time lapse between initial and final conversion is expected to be rather short.

Figure 1 shows the plan for calling from automatic to manual. The calling subscriber dials a single digit, say "9", thereby signalling the manual operator, who answers and completes the call manually in the customary manner. The trunks from the automatic equipment would terminate on answering jacks in the manual board, or on single-ended cords in the case of "B" positions. It is not necessary to change the directory numbers of the manual subscribers. However, these numbers should have some identifying mark, so that the subscribers having automatic telephones will be able to recognize them as numbers of manual stations. The trunk circuits between the automatic and manual equipment would be of the simplest possible design, since it is doubtful if they could be re-used in the final conversion.

Figure 2 shows the plan for calling from manual to automatic. In this plan, a group of trunks from the manual board terminate in the automatic equipment on operators' first selectors. The

banks of these selectors are multipled with the banks of the local first selectors, thus enabling the operator to dial the wanted automatic subscriber's directory number.

With this plan it is necessary to equip the manual positions with dials, and either to modify the cord circuits for dialing, or to provide a dialing cord for each position. There will also be required the necessary trunk circuits to the operators' selectors. Completion of calls from manual to automatic will be somewhat slower than from manual to manual. In the final conversion the operators' selectors may be re-used without any changes, but it is doubtful if the trunk circuits could be re-used.

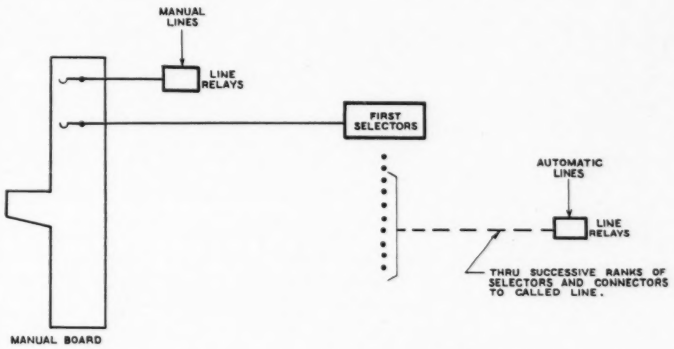


Figure 2. Straightforward plan: calling from manual to automatic.

Call Indicator Trunking

In multi-office areas, or in larger single offices where the inter-system traffic is heavy or where a grade of service is desired in which automatic subscribers are not required to discriminate in any way between the calling of automatic or manual numbers (or even to know *whether* the called station is automatic or manual), an apparatus known as "Call Indicator" is frequently used.

The general plan of call indicator trunking is shown schematically in Figure 3, and a typical call indicator position is shown in Figure 4. The equipment consists in general of trunk circuits, the number of which is determined by the traffic from automatic to manual stations. These trunk circuits terminate on single-ended cords in manual "B" positions. Associated with each cord is a "trunk assignment" lamp and a "trunk disconnect" lamp.

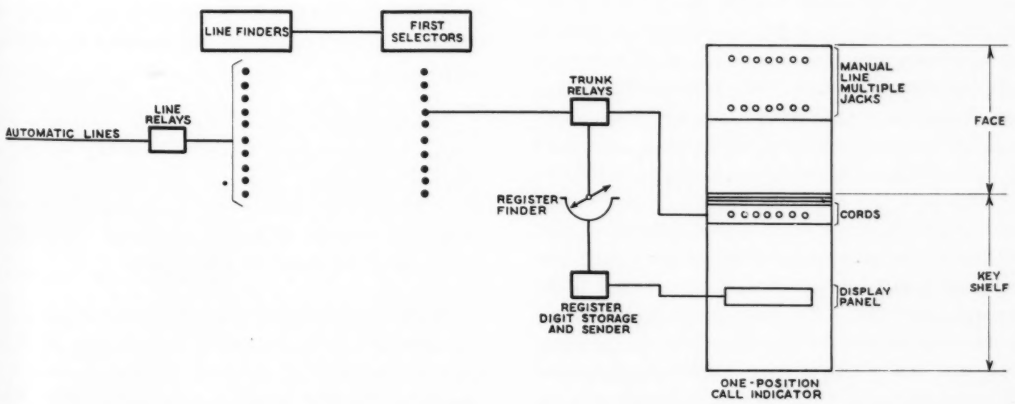


Figure 3. General plan of call-indicator trunking.

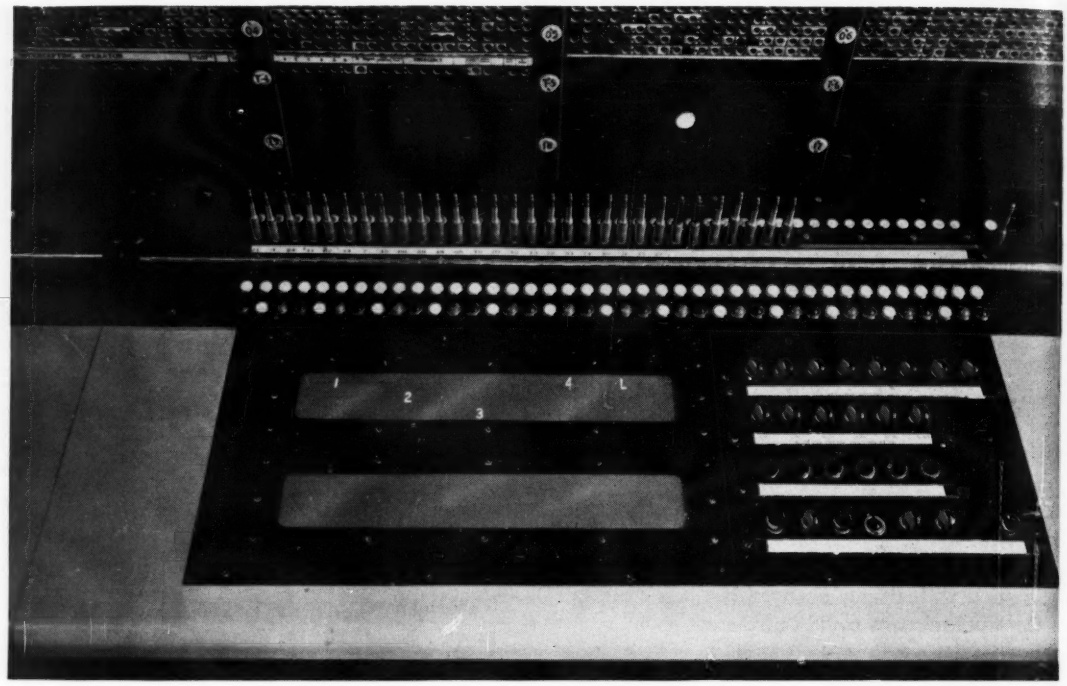


Figure 4. A typical call-indicator position.

There is also associated a register, for receiving, storing and sending the dialed impulses and displaying the dialed number on a lamp display panel mounted on the keyshelf of each "B" position.

When an automatic subscriber calls a manual number, as for example 7-6894, the dialing of the first digit (7) selects an idle trunk circuit. Simultaneously, through the operation of the register finder, a register automatically becomes connected to the trunk circuit. The next four digits (6-8-9-4) are dialed into the register, where they are stored on digit storage switches. Upon completion of dialing, the four last digits (6-8-9-4) of the called number are displayed on the lamp display panel, and the trunk assignment lamp of the cord associated with the selected trunk circuit will glow. The operator notes the displayed number, picks up the plug of the cord indicated by the glowing lamp, and if the called line is idle completes the call by plugging into the multiple. Ringing is automatic from the trunk, and ringing tone is sent back to the calling subscriber. If the call tests busy, the operator momentarily depresses a busy key common to the position, and busy tone is sent back to the calling party from the trunk circuit. This also disconnects the trunk circuit from the call indicator position. The act of plugging into the multiple, or depressing the busy key, extinguishes the displayed number and disconnects the register from the trunk circuit, thereby freeing the register and the call indicator position for another call.

The first digit (7) of the dialed number is generally not displayed, since it is either the office digit or the group digit for the manual numbers. If, however, the numbering plan is such that the first digit must be displayed, provision for so doing can readily be made in the register.

A directory number change will be required for the manual lines, in order to conform with the display facilities of the call indicator. As far as possible, the new number assignments should follow the plan which will be used in the ultimate conversion to automatic operation. It may, however, not always be entirely possible to do this,

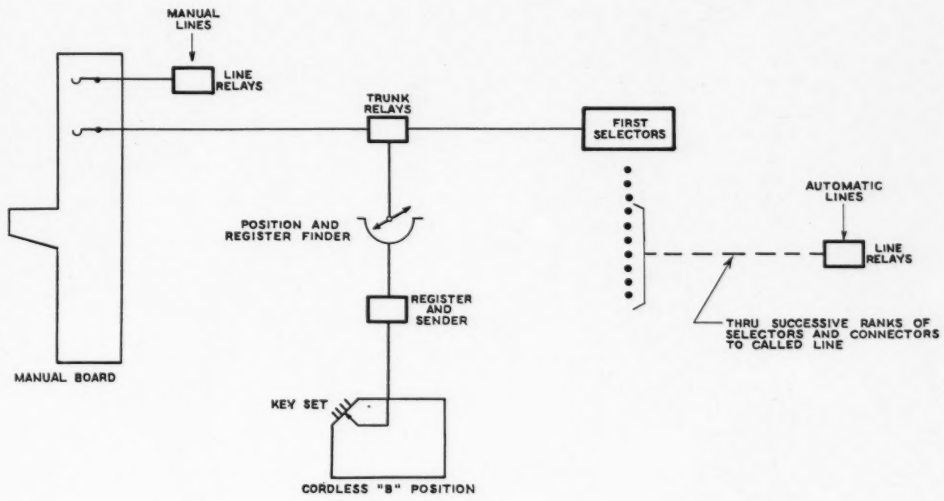


Figure 5. Trunking arrangement of plan using keysending cordless "B" positions.

particularly in cases where the automatic lines are operated on a terminal-per-station basis while the manual lines remain on a terminal-per-line basis.

In view of the relatively high cost of call indicator equipment, and since it cannot be re-used in the final conversion to full automatic operation, its application is generally confined to areas where such an investment in temporary equipment can be justified only from the economic or grade-of-service viewpoints.

The number of calls which can be handled on call indicator positions is generally from 400 to 500 per hour per position. This, however, is contingent upon the efficiency of the operators, number of positions installed and the resultant operator teamwork.

Cordless "B" Positions

On calls from manual to automatic, where faster manual operation is desired than can be attained by the straightforward method described in connection with Figure 2, or when for various reasons it is not practical to convert the existing manual positions for dialing, it is the general practice to provide keysending cordless "B" positions. Figure 5 shows schematically the trunking arrangement of such a plan, and Figure 6 shows a typical cordless "B" keysender board. The equipment consists, in general, of a number of cordless "B" positions (as required to carry the traffic) together with associated trunk circuits, register finders, registers and senders. The trunks from the manual board are terminated on trunk circuits, which, in turn, are directly connected to operators' first selectors.

When receiving a call for an automatic station, the "A" operator plugs into a jack, which is connected to an idle trunk circuit and its associated operator's first selector. Through the trunk finder the "A" operator is instantly connected to a cordless "B" position, and the glowing of a lamp in that position indicates to the "B" operator that her position is connected to a calling trunk. A momentary "zip-zip" tone now becomes audible to both operators. The "A" operator then passes the called subscriber's number to the "B" operator, who in turn, successively depresses the numerical keys on her keyset corresponding to the digits of the number passed by the "A" operator. Each digit is registered as its corresponding key is depressed, and a sender is caused to send the corresponding impulses over the trunk to the oper-

Figure 6. A typical cordless "B" keysender board in operation.

ator's first selectors and successive ranks of switches, thereby extending the connection to the called line.

After the "B" operator has set up the digits, she operates a "clearance" key common to the position, thereby releasing the positional equipment and making it available for another call.

The calling and called subscribers are connected together through the trunk circuit and automatic switches, and the "A" operator has full supervisory control of the connection. When the "A" operator disconnects, all switches except the connector release. The release of the connector is, as in the case of an ordinary local call, under the control of the called party.

General experience has indicated that from 600 to 800 busy hour calls usually can be handled by means of cordless "B" trunking. The equipment is relatively expensive, and in the final conversion only the operators' first selectors can be re-used.

Multiple of Manual and Automatic Lines

A somewhat different plan of interconnection may be used when the automatic and manual equipments are located in the same building. This plan, which is shown in Figures 7 and 8, provides a connector bank multiple of the manual lines, and a manual multiple of the automatic lines. This arrangement permits automatic subscribers to dial all manual subscribers direct, and also permits manual-to-automatic calls to be completed by the operator plugging into multiple jacks associated with the automatic lines.

Consider, first, calls from automatic to manual, as shown in Figure 7. The calling subscriber dials the directory number of the wanted station, and need not in any way be concerned whether that station is automatic or manual. The connectors are divided into two groups; one group is associated with the automatic lines, and the other group is associated with manual lines. The banks of the connector groups associated with the manual lines

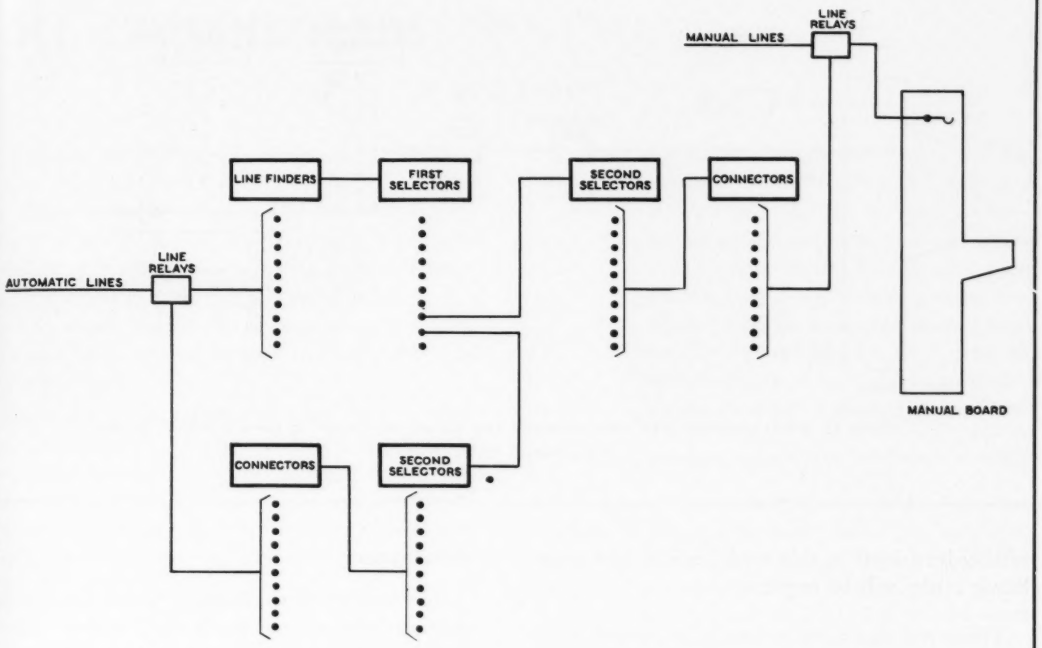


Figure 7. Interconnection plan with automatic and manual equipment in same building: calling from automatic to manual.

are multipled with the manual line circuits, in order to permit the manual lines to be called. The wiring of these connectors differs somewhat from that of the connectors serving the automatic lines, in order to permit operation with the manual line circuits.

This plan requires changing of the manual subscribers' directory numbers to conform with the numbering of the connector groups which will be assigned for calling the manual lines. Separate groups must be provided for P.B.X., individual and party lines.

Under this plan all of the automatic switching equipment will become part of the ultimate arrangement of full automatic operation. As automatic lines are added to replace manual lines, the connectors in the replaced manual groups will, by a minor wiring modification, be changed to function with the automatic lines. Since the plan involves a considerable initial investment, it appears that its application would be limited to projects wherein the transition period is expected to be relatively short.

Figure 8 shows, schematically, the plan for calling from manual to automatic stations by merely plugging into the manual multiple of the automatic lines.

The automatic line circuit used with this plan requires, in addition to the customary line and cut-off relays, a translating relay for the purpose of interconnecting the busy test on the manual board (negative battery on the sleeve) with the busy test of the automatic switches (positive battery on the control lead). Some manual boards are equipped with line circuits which, with some modification, may be used as translating relays, thus obviating the need of new relays for this purpose. However, if the manual line circuit does not

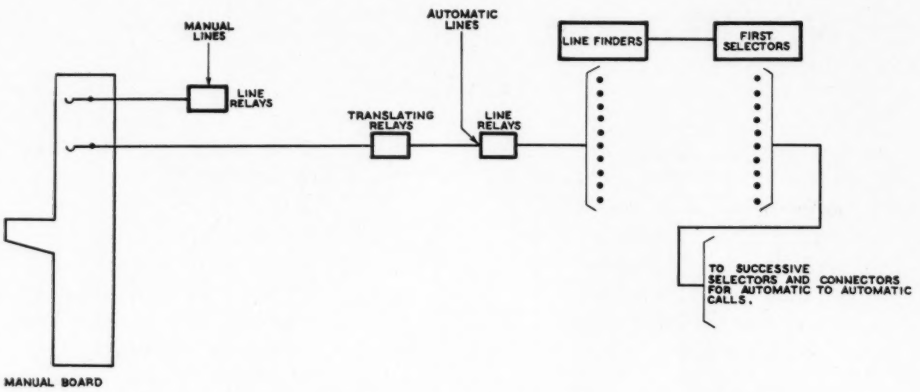


Figure 8. Interconnection plan with automatic and manual equipment in same building: calling from manual to automatic.

readily lend itself to this modification, new translating relays will be required.

There will also most generally be needed additional jacks in the manual board for multiple appearances of the automatic lines. This is particularly the case if the automatic addition is primarily intended to provide additional subscribers' line facilities, rather than to effect relief on the manual board by the transfer of lines from manual to automatic service. The availability of adequate space in the manual board for these jacks is often a deciding factor as to the possibility of carrying out this plan.

The plan shown in Figure 8 and outlined in the preceding paragraphs will give the fastest possible service for manual-to-automatic calls. Since none of the line translating equipment can be reused in the final conversion, the application of the plan will necessarily be limited to those partial conversions where such an investment in temporary equipment can be justified.

Conclusion

The various plans discussed herein for interconnection between automatic and manual systems do not necessarily need to be considered as interrelated in the sequence in which they are described. For example, the plan employing the connector bank multiple of the manual lines for calling from automatic to manual, as shown in Figure 7, may, if desired, be used equally well with either the straightforward plan shown in Figure 2 or the cordless "B" board plan shown in Figure 5 for calling from manual to automatic. The important point is that some plan, or combination of plans may satisfactorily be worked out to provide automatic service for part of the lines, with facilities for calling between the automatic and manual systems, until the final conversion to full automatic operation is consumated. The plan to be selected must obviously be that which, from both the economic and service viewpoints, will best meet the requirements of the particular project being considered for conversion.

AUTOMATIC ELECTRIC CORD-TYPE TOLL SWITCHBOARDS

By R. C. CHOCK

***SYNOPSIS:** Trends in toll traffic—"automatic" and "cord-type" boards—delay and C.L.R. arrangements—handling inward and outward traffic—the Type 30 toll board—the Type 20 toll board—structural design and other physical features—cord circuit, operator's telephone and position circuit—lines and trunks—miscellaneous services and equipment.*

IN recent years there has been a great increase in the toll telephone traffic in the United States. The development of intertoll dialing systems in many parts of this country and Canada, added to this traffic increase, has made necessary progressive modifications of toll switchboard equipment to enable operating companies to meet the new conditions and to handle the increased load efficiently.

These trends in toll traffic have been accompanied by marked activity in the development of automatic toll boards, and attention in the industry has largely centered on this newer type of equipment. Meanwhile, however, there have been parallel developments and improvements in cord-type toll equipment, but very little discussion of this work and its results.

Automatic Electric Company manufactures both automatic and cord-type toll boards to meet the requirements of large and small exchanges. Because many operating companies find cord-type boards best suited to their needs, Automatic Electric engineers have been constantly improving cord-type equipment to meet the needs of today's expanding toll telephone field. It was thought to be of some value to outline here some of the salient features of these improved cord-type boards, to guide interested telephone companies in the planning of their toll facilities.

"Delay" and C.L.R. Arrangements

In the earlier days of long-distance telephony, toll calls were handled, for the most part, on a "delay" basis. That is, they were not completed immediately because of equipment limitations and a shortage of toll circuits. Today, however, there are better equipment and circuit facilities, and the general practice is to complete the call immediately while the subscriber waits on the line. This method of handling toll calls is called *C.L.R.* (Combined Line—Recording)

Immediate completion of the call is not always possible, however, for a variety of reasons. When a C.L.R. operator is unable to complete the connection within a reasonable time, the recording ticket is sometimes passed to a "Delay", or "TX" switchboard position. This is a specially designated position in the C.L.R. group for the completion of delayed calls, and takes over from that point in the process.

Handling Inward and Outward Traffic

Larger toll boards are usually made up of two types of positions: *Inward or Through* positions; and *C.L.R.* positions. The former complete calls from distant toll centers to local subscribers or through to other toll centers on the outside. The C.L.R. positions handle outgoing calls from the local area to distant toll centers.

On smaller boards, however, it is sometimes advantageous to have all the positions handle *both* inward and outward traffic; these are usually referred to as "combination" positions.

Intertoll dialing, which is being rapidly extended in the United States and Canada, has decreased the need for inward positions. This is because with the intertoll system, the originating outward operator sets up and extends a toll call directly to the called terminal, when that call is destined for a subscriber in an automatic exchange.

The Type 30 Toll Board

On new installations, the Automatic Electric Type 30 toll board is usually provided, since it

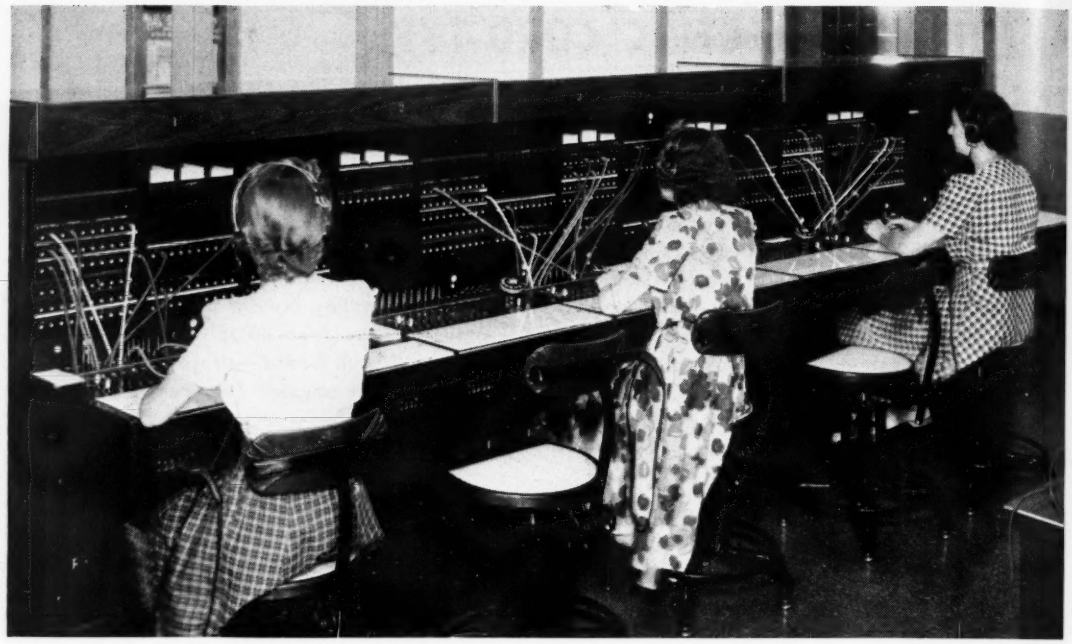


Figure 1. Typical Installation of Type 30 Toll Switchboard.

meets all the requirements for nationwide toll dialing. (See Figure 1.) This board has provisions for both *line termination* and *pad control.*

The *line termination* feature provides for the automatic placing of resistance and capacitance bridges in the circuit to prevent "singing" if a voice repeater is connected. *Pad control* is necessary in offices where terminal repeaters are provided. In pad control, an artificial loss, or "pad" is automatically placed in the circuit when an incoming call is terminated locally; the high-level volume is thus reduced to a specified level. The pad is automatically disconnected, however, if the call is switched to another toll center, where the high-level volume is needed for transmission.

The Type 20 Toll Board

Where the toll requirements are simple, and the primary purpose is for D.S.A. (dial service "A" board) service, and where pad control need not be considered, the Automatic Electric Type 20 toll board may be used.

The Type 20 toll circuits are considerably simpler than those in the Type 30 board. In the former, ringing current is placed directly on the front or rear of the cord circuit and thence over the line by operation of the ringing key, in the same manner that ringing is accomplished on a conventional manual switchboard.

In the Type 30 board, however, direct current is placed on the cord circuit when the ringing key is operated; this causes a relay in the toll line to operate, which places 20-, 135-, or 1000-cycle current directly on the line, instead of from the cord circuit via the ringing key.

Whether the toll circuits used are Type 20 or Type 30, the operation of the supervisory relay equipment is identical. This equipment is associated with the trunks and lines, and permits—in either case—the use of a comparatively simple cord circuit.

Automatic Electric cord-type toll boards are designed for 48-volt operation, which is the same voltage required for associated automatic exchange equipment.

General Structural Design

The toll board section usually supplied is of the low type, although a high section is available for large toll boards. Dimensions of the sizes of sections are as follows:

Two-Position, 5-Panel Section	*Low Type*	*High Type*
Length	4′ 9-1/32″	4′ 9-1/32″
Height	4′ 8-7/8″	7′ 7-1/16″
Depth	3′ 2-3/8″	4′ 8-7/16″
Jack Panel Opening	1′ 4-9/16″	2′ 9-1/16″
Trunk Capacity	700	1500

The frames are of unit-type steel construction. Woodwork is attached to the steel frame; exterior woodwork usually is of birch with a dark mahogany finish, although oak or walnut woodwork may be supplied. The keyshelves, plugshelves, pilot rails and lock rails are covered with black phenol fibre, providing a hard, durable surface which requires no refinishing.

In front of the keys on the keyshelves, ample writing space is provided by a removable glass bulletin holder, under which routing instructions and the like may be placed.

Other Physical Features

The high-type section is provided with a metal roller curtain in the rear instead of the conventional wooden lift-out door.

A cable-turning section, or box panel, is provided at the non-growing end of the switchboard for the entrance of cables. The end panel at the growing end is removable, and can be relocated when additional positions are added.

A pin rack is provided in the rear of the jack field to support the short multiple cables between jack appearances in a neat and orderly manner. Between the two positions of each section a space is provided for a time stamp, usually a Calculagraph, for indicating the duration of the toll call. A clock may be used in lieu of a time stamp if ticketing of toll calls is light, such as in the case of A-B toll handling.

The Calculagraph ordinarily provided is for operation from a 110-volt, 60-cycle supply, stepped down to 20 volts through a transformer; however, 50-cycle operation can be provided for. The Calculagraph may also be had with a motor to operate directly from 110-volt, 60-cycle current, when required.

The plugshelf is drilled for the plugs and associated number plates (14 cord circuits in inward positions and 10 in the C.L.R. positions). A fibre plug bushing is provided for each plug drilling to minimize wear. Individual plug seats are provided for the plugs. Small plastic cord bushings are placed on each cord directly back of the plug to reduce cord wear, and to practically eliminate noise incidental to the seating of the plugs.

Ticket pockets can be provided to permit a toll ticket to be placed adjacent to the keys of the cord circuit being used on a particular toll call. The ticket will extend a short distance above the top of the key escutcheon. One pocket per cord circuit can be provided in the C.L.R. positions. In the inward positions very few tickets have to be made, so only one or two pockets are provided.

The cords of each position are alternately colored red, white and green, to give the operator a visual aid in taking down the cords when a conversation is completed. The corresponding cord supervisory lamps are similarly colored.

The jack equipment can be supplied ten per strip or twenty per strip, depending on the number of lines and trunks required. Small toll boards ordinarily are supplied with ten-per-strip jacks and lamp jacks.

Lamp busy strips are provided for indicating a busy condition of a line or trunk. These strips have the appearance of a regular designation strip, with ten or twenty small holes in line with the lamps in the rear. A thin strip of fibre, through which the light shines, provides a distinctive non-glare busy indication.

On large toll boards idle line indicating can be provided. In this case, idle indicating lamp strips, which occupy the same space as the regular busy lamp strips and have the same general appearance, are provided. Instead of permitting a lamp for each busy line to light, only one lamp will light above the next available line or trunk in a group. While an additional relay per line is required for

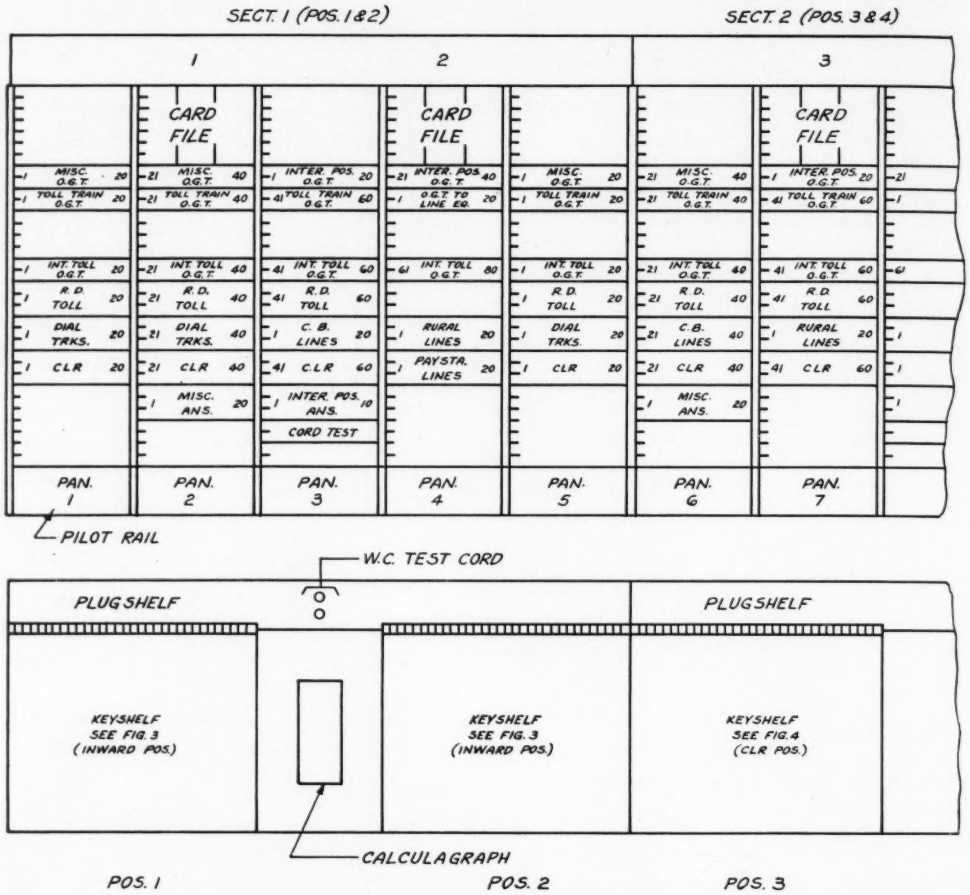


Figure 2. Jack-panel Layout of Typical Toll Board on Four-panel basis.

this feature, there will be considerably more current saved by having only the next non-busy trunk indicated than by having all busy lines and trunks indicated by lighted busy lamps. Usually, a group of trunks appearing on one strip of 20 jacks will be divided into sub-groups of five, so that there will appear four idle-line indicating lamps for the group. At night, the group can be conditioned to cause but one lamp for the group to light, if desired.

The lines and trunks of toll boards are usually on a four- or five-panel multiple basis. The plan adopted depends largely on the total number of circuits and preferences of the telephone company. The layout of a typical toll board on a four-panel basis is shown in Figure 2. The use of head and foot two-panel sections to provide for an extension of the jack multiple makes it possible to use a six-panel multiple within reach of the first and last operators as well as the intermediate operators.

One-way incoming circuits, such as C.L.R. trunks, are located in the lower portion of the jack panel. Two-way circuits are located above the incoming circuits, while the one-way outgoing circuits are located in the uppermost portion of the jack field.

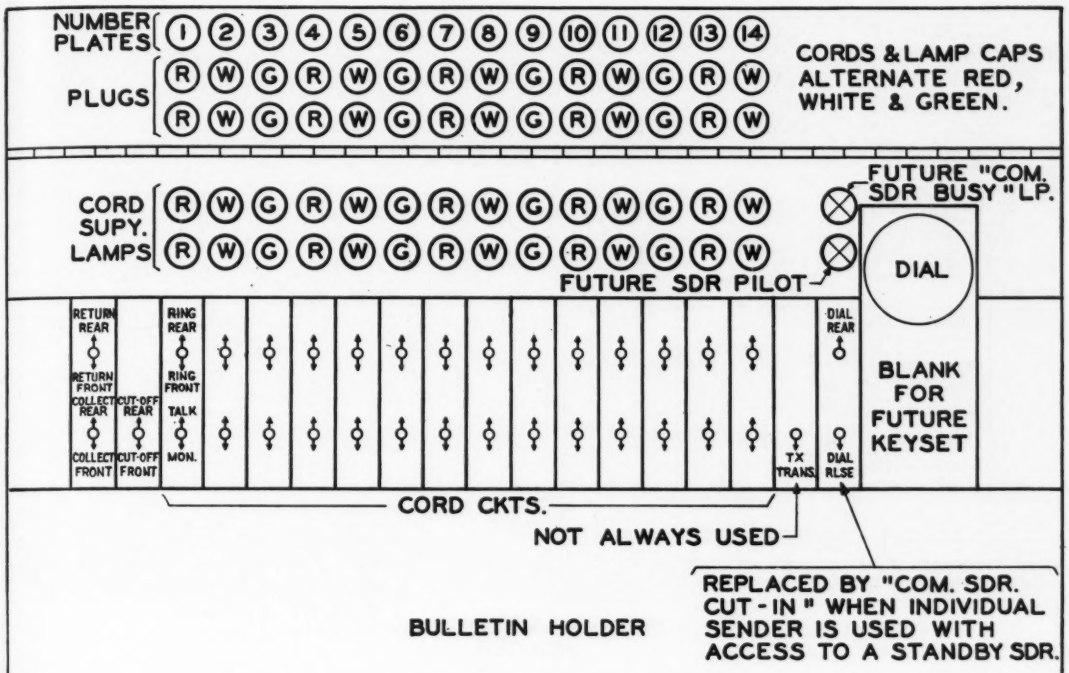

NUMBER PLATES
1 2 3 4 5 6 7 8 9 10 11 12 13 14
PLUGS
R W G R W G R W G R W G R W
R W G R W G R W G R W G R W
CORDS & LAMP CAPS ALTERNATE RED, WHITE & GREEN.
CORD SUPY. LAMPS
R W G R W G R W G R W G R W
R W G R W G R W G R W G R W
FUTURE "COM. SDR BUSY" LP.
FUTURE SDR PILOT
DIAL
BLANK FOR FUTURE KEYSET
RETURN REAR
RETURN FRONT
COLLECT REAR
CUT-OFF REAR
COLLECT FRONT
CUT-OFF FRONT
RING REAR
RING FRONT
TALK
MON.
TX TRANS.
DIAL REAR
DIAL RLSE
CORD CKTS.
NOT ALWAYS USED
REPLACED BY "COM. SDR. CUT-IN" WHEN INDIVIDUAL SENDER IS USED WITH ACCESS TO A STANDBY SDR.
BULLETIN HOLDER

Figure 3. Keyshelf—Typical Inward and Through Position.

Cord Circuit, Operator's Telephone and Position Circuit

The cord circuit is arranged for ringing on either cord. The talking key, when operated, permits the operator to talk to both subscribers simultaneously.

Inward positions can be wired for an ultimate of fourteen cord circuits. C.L.R. positions are usually wired for ten cord circuits. Figures 3 and 4 show keyshelf layouts for typical inward and C.L.R. toll positions, respectively. In Figure 5 is illustrated the keyshelf and plugshelf of a typical toll position.

The monitor key permits the operator to monitor a call after the connection has been established. The operator is able to hear the conversation of both parties without disturbing the transmission circuit, but is unable to talk to either party.

The common "cut-off front" and "cut-off rear" keys permit the operator to talk to either the calling subscriber or the called subscriber privately by the operation of the talk key in conjunction with one of the cut-off keys.

The operator is able to dial on the front cord by merely operating the talk key and the dial or keyset. If dialing over the rear cord is required, the operator must operate the dial rear key of the position circuit and the talk key of the cord circuit. If the dialed line is busy and the busy condition indicated by busy tone, the operator receives the tone in the receiver of her telephone circuit.

In case the connection is dialed over an intertoll trunk where "flash busy" is returned when the dialed line is found busy, the associated trunk causes the corresponding supervisory lamp to flash as a busy indication.

Where no key is furnished, a dial pilot lamp is provided which will indicate when the switching equipment in the distant office or at any intermediate point is ready to receive pulses. The oper-

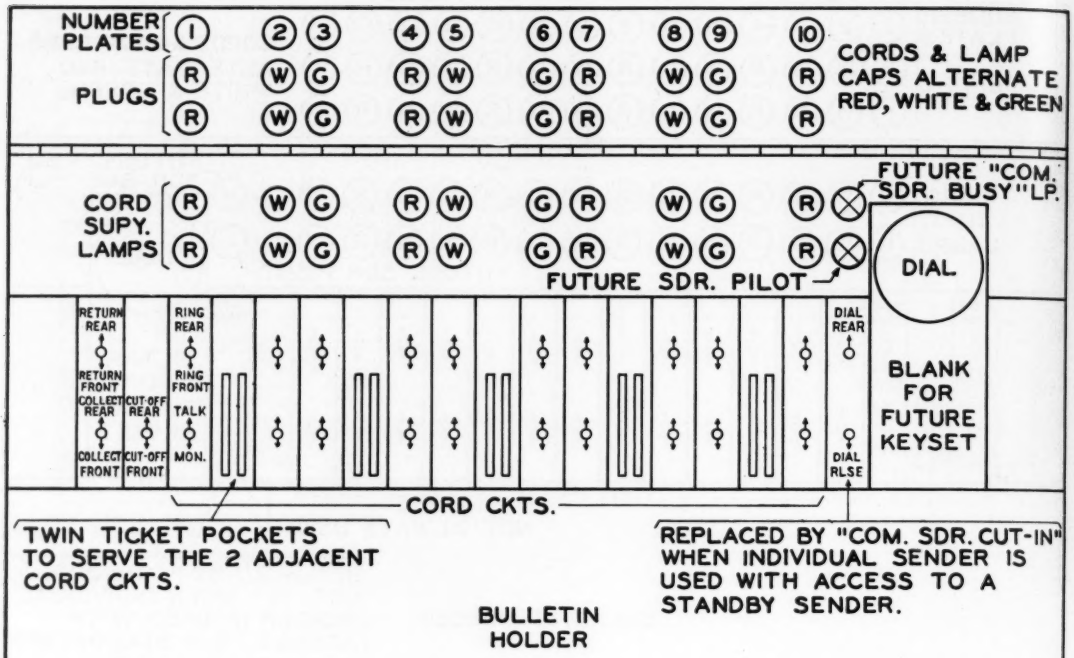


Figure 4. Keyshelf—Typical C.L.R. and TX Position.

ator starts to dial or continues to dial only when the dial pilot is lighted. When key senders are used the operator may send the complete code and retire from the connection without observing stop-dial signals.

Operation of the collect or refund keys of the position circuit permits the operator to collect or refund deposited coins.

The automatic ring key provided on inward positions, when operated, will cause the start of the ringing automatically on calls to local subscribers via the toll train.

Supervision is accomplished by relay action in the trunk circuits or line circuit, which causes the resistance of the sleeve circuit to be decreased sufficiently to allow the supervisory lamp to light.

The function of the TX transfer key is to allow the inward operator of a large toll board to transfer the incoming line signal of tributary calls which require ticketing to appearances in certain C.L.R. positions. The incoming call will light a lamp in the inward position. When the operator ascertains that a ticket has to be made she operates the common TX key of the position circuit, which causes the answering lamp to light in the assigned C.L.R. positions for handling. The inward operator can immediately retire from the connection.

Double transfer keys can be provided to enable the operator to transfer calls to either one of two designated locations, depending upon whether the transfer key is operated forward or to the rear. The double transfer requires special line and trunk circuits.

Lines and Trunks

The following lines and trunks are usually provided on toll boards: (Principal ones are shown in Figure 6.)

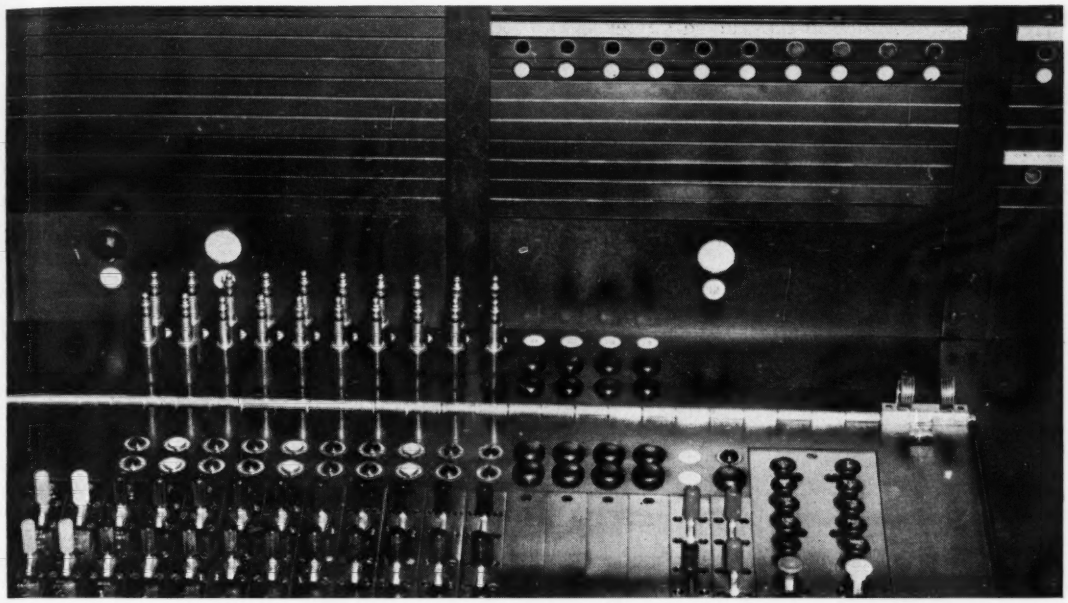


Figure 5. Manual Toll Board Keyshelf Position Showing Keyset at Lower Right.

1. Ring-down Toll Lines

Incoming ringing current causes a relay in the associated signal receiving circuit (usually 20 cycles) to operate and light the answer lamp in all appearances. On outgoing calls the operation of the ringing key of the cord circuit will cause ringing current to be placed on the line. As explained before, the ringing current is placed on the circuit directly by the ringing key in the Type 20 toll boards, while in Type 30 toll boards the ringing current is placed on the line by a relay in the R.D. toll line relay equipment.

In intertoll networks, it is often desirable to permit the distant outward operators of toll centers to have access to Ring-down Toll lines in the terminating office. Automatic Electric Company can supply Ring-down Toll line circuits arranged to be accessible from intertoll selector levels.

2. Intertoll Dial Lines

Where intertoll dialing is introduced, inward traffic to the toll board is reduced, since the distant toll operator is enabled to dial the wanted subscriber direct. On outgoing calls the toll operator can plug into the outgoing intertoll trunks to reach the distant office, or toll center, instead of being required to use local switching equipment. Loop dialing, SX dialing or composite (CX) dialing can be provided for. Battery pulsing with battery, and ground signaling for SX-CX, or the polar-duplex composite arrangement usually provided by Bell for long-haul circuits can be arranged. A.C. dialing (50 or 60 cycles) for short haul circuits, voice frequency dialing (VFD) and dialing at carrier frequencies for carrier systems can also be provided.

3. C.L.R. Trunks (Regular)

C.L.R. (combined line and recording) trunks are reached by local subscribers desiring toll service usually by dialing 0, 110, 211 or other code set up by the telephone company. The inclusion of a re-ring feature is desirable as it will permit the operator to recall a P.B.X. operator or individual line subscriber.

4. C.L.R. Trunks (Paystation)

This circuit is used as a toll recording completing trunk reached by pre-pay paystation lines, and is arranged to refund automatically the deposited coin when the toll operator answers. After the

call has been extended to the wanted distant station or subscriber, the operator requests the calling party to deposit the required amount of money. The operator may collect the money either before or after the calling party disconnects. The toll operator may re-ring the calling subscriber over this trunk.

5. *Toll Terminal Lines*

Where subscribers make extended use of toll facilities in carrying on their business, direct lines or toll terminal lines (central battery) can be provided which will permit such subscribers to receive prompt service on both incoming and outgoing calls.

6. *Manual Paystation Lines*

These are central battery lines which terminate on the toll board. The paystation requires no dial, and the subscriber drops coins as requested by the operator before conversation starts.

7. *C-A-X Trunks*

Trunks involving outlying community automatic exchanges (C-A-X) or community dial offices (C.D.O.) are of various types. Some trunks are

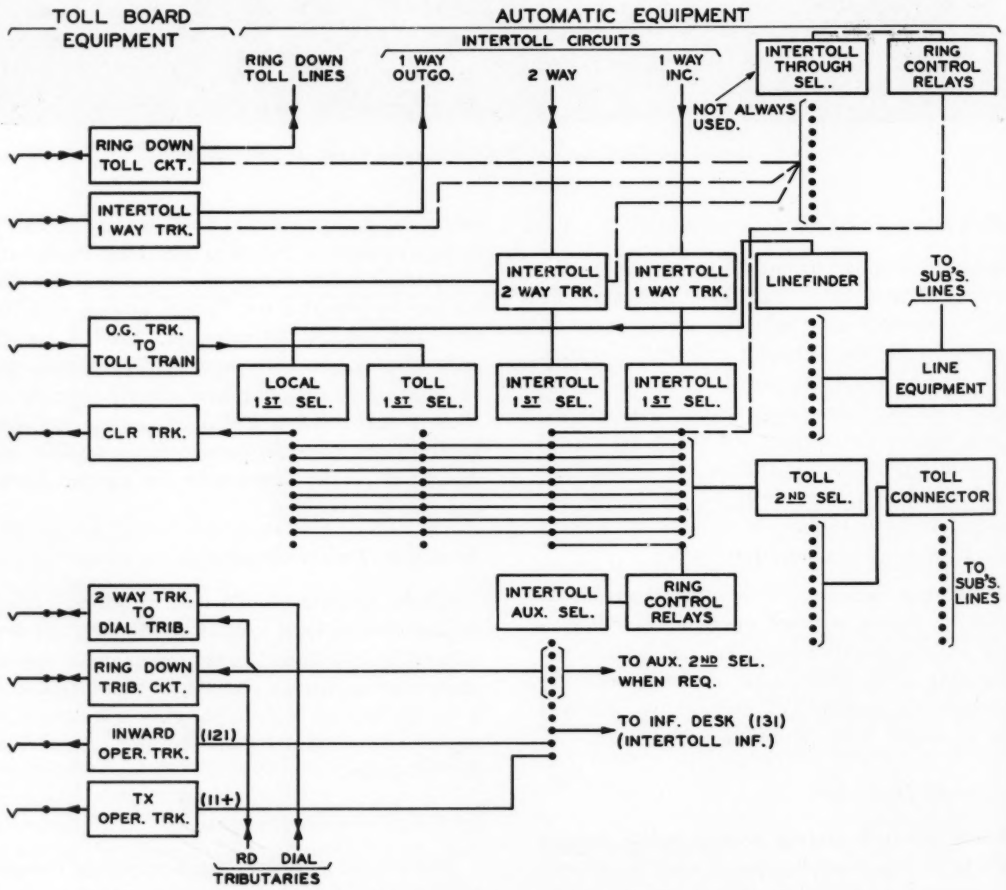


Figure 6. Schematic Trunking Diagram Showing Toll Switchboard and Intertoll Switching in a Toll Center Office.

outgoing only from the toll board, as the (C-A-X) subscribers are permitted to dial directly into the parent office. Some other trunks are terminated only at the toll board. Loop dialing, SX dialing or composite (CX) dialing can be provided for.

8. Rural Lines (Manual)

Magneto lines for rural service can be provided. Single-frequency code ringing can be provided for only on the Type 30 toll board. Harmonic ringing can be provided for on the Type 20 toll board.

9. Rural Trunks (Selector Levels)

These are trunks from selector level reached by dialing a special code. The operator will at once know that the party desires connection with a rural subscriber when the call appears on the jack group assigned for this service.

10. Trunks to Toll Train (Regular)

These are trunks which are used to extend incoming calls to the local subscribers. High grade transmission is provided, and flash busy indication —instead of tone busy—is given to the operator.

11. Trunks to Toll Train (Paystation)

These trunks are similar to regular trunks to toll train except that added facilities are included for the collecting and refunding of coins.

12. Trunks to Line Equipment or Operators' Selectors

Where a toll train is not required, trunks to operators' selector, or trunks to line equipment are provided. Sometimes it is advantageous to provide overflow trunks (trunks to line equipment) for connecting rural lines to local, etc., where high grade toll transmission is not required.

13. Call-Order Trunks

These are trunks used to reach a call-order operator in case a distant operator encounters difficulty in reaching an idle trunk in a trunk group. It is the function of the call-order operator to obtain, if possible, a trunk in the desired group when one becomes available and to call the distant operator desiring to reach this trunk. Call-order trunks are provided only at through-switching toll centers.

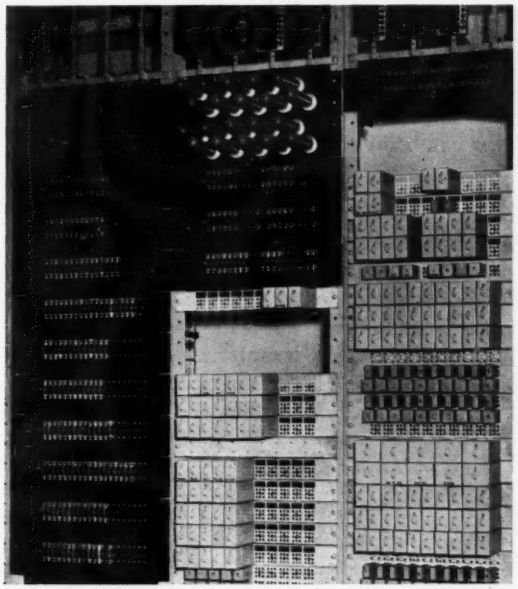


Figure 7. A Portion of Typical Manual Relay Rack.

14. Information and Repair Service

On small boards these services are often handled by the toll operators. Usually one appearance, or possibly two appearances, are sufficient. On larger boards this service is sometimes transferred from the desks which handle this service during the day to the toll board for handling at night.

15. Intercept Service

This service is handled the same as is Information and Repair, outlined above.

Intercept service of the following types can be provided:

Connector Intercept (Straight Line)

Connector Intercept (Traffic Ringer) For party-line intercepting

Selector Level Intercept (Local)

Selector Level Intercept (Toll)

With intertoll dialing it is important to provide the distant outward operators with intercepting facilities so that correct information on attempted calls to unassigned, changed or disconnected numbers can be obtained.

16. Inward Operator Trunks

Where intertoll dialing facilities are provided, inward operator trunks are provided to enable the distant operator to contact the toll board when special handling of the call or assistance is required. The inward operator may signal the originating operator by operating her ringing key. Dial-code 121 is used for reaching the inward operator.

17. Verification Trunks

These trunks are used by the toll operator to determine if the called line is actually busy or out of order. She can also verify if the subscriber has given his correct number on an outgoing (ticketed) call.

18. Cord Test

This is a simple testing circuit multipled in every section of the toll board to make tests for noisy cords, to make cord supervisory lamp tests and to connect the dial of a position to the test desk for checking dial speed and pulse ratio.

19. Door Opener Circuit

This is a common-battery line connected to a telephone in the outside vestibule of the telephone office. When a person desires to enter the building, he identifies himself over this telephone, and the operator can open the door by operating an electric door release key.

20. Supervisor's Circuit

A supervisor's circuit is usually provided for each division of six positions. When an operator in a division wishes a supervisor, she will plug into the O.G.T. jack designated "SUPVR" and ring. This will cause the supervisor's pilot for the division to light and a bell to be sounded. Each two-position toll section is equipped with a supervisor's answering jack and associated "Hold" and "Flash" keys located in the lock rail below the Calculagraph shelf.

21. Rate and Route Trunks

These are one-way trunks from the toll board to the rate and route desk or the information desk (as the case may be) to provide information on the routing of calls or on toll rates.

22. Toll Information Trunks

These are one-way trunks to the information desk for directory service. Often toll information and rate and route trunks are placed in one common group.

23. W. C. Test Cord

A test cord located in the plugshelf to the rear of the Calculagraph in one section is provided so that a through test may be made by the wire chief after the plug is inserted into a line jack.

24. Trunks to Other Desks

Instead of order wires, it is Automatic Electric's practice to provide for two-way trunks to other desks, such as repair, test desk, test panel and chief operator. For calling between operators on the toll board, interposition and TX trunks are provided.

25. Interposition Trunks

The outgoing trunk jacks for this service are cables to the I.D.F. for cross-connecting to the answering jacks. This arrangement permits the grouping of a number of trunks in front of several operators to meet traffic requirements.

26. TX Trunks

When the distant operator locates a party on a delayed call and advises the "inward" operator of the "we have" notification, the inward operator will use a TX trunk to extend the call to the delay operator handling the call. The TX transfer key previously described is not used for this service. This TX operator, by operating her ringing key, can signal the distant operator originating the call.

The above description covers the method used when intertoll dialing is not in the set-up. When intertoll dialing is involved, the distant operator will dial the regular TX code 11- (111, 112, 113,

etc.) to reach the particular operator holding the ticket, directly instead of via the inward operator.

27. Operators' Training Circuits

Provisions for operator's training equipment are usually made on large toll boards. Regular C.L.R. positions are arranged to permit an instructor and one or two students to simulate all types of calls, tones and flashing signals. The instructor serves as a local party, distant toll operator or supervisor. When not used for instruction purposes, the positions function as regular C.L.R. positions.

28. Night Answering

At night or during light load periods, service handled by the Information desk, Repair desk, Rate and Route desk, etc., may be switched to the toll board for handling.

29. Flashing Circuit

A flashing circuit can be provided in connection with trunks, which will cause the line lamp of the trunk to flash if the operator does not answer within a pre-determined time. This involves elaborate equipment, and is not therefore usually provided.

Key Senders

The use of keysenders is becoming more and more popular in this country with the advent of intertoll dialing. In order for the toll operator to dial through the distant automatic exchange to the subscriber wanted, a total of ten or more digits must be sent. The use of a keyset with light touch keys makes the sending of digits a simple task.

Keysenders can be provided on the basis of: one group of senders for the entire switchboard; individual senders; or individual senders for inward positions and a common group of senders for the C.L.R. positions.

The digit registers are of the reflex type, which allow some of the registers to be re-used for digits. When the first digit key is depressed, the first digit is immediately sent; therefore, if a nine-digit register is used, the tenth digit is stored in digit register No. 1, etc., the limitation, of course, being the speed of setting up the digits by the operator and the number of digits set up.

Miscellaneous Services

Where the size of the exchange is not large, special services such as fireman's lines, C.A.X. alarms, secretarial service, and official P.B.X. are sometimes provided.

Ticket carriers can be supplied to transfer uncompleted tickets to TX or delay operators and completed tickets to a special operator for sorting. A number of tracks—usually four or five—which are simply long metal bars suspended by brackets, are installed above the jack field. The carriages are suspended mono-rail fashion, and are operated by a flick of the hand. On larger boards a pneumatic tube ticket distributing system can be provided.

Relays for cord circuits, operators' telephone circuits, position circuits, and auxiliary signal circuits are mounted on swinging racks in the rear of the positions. All other relays for lines and trunks are mounted on external unit-type relay racks.

The external relay racks are usually provided in two heights: 9′-0″ and 11′-8″. The terminal blocks (maximum of 4) are located at the top of the rack. Immediately below, the fuse panels are mounted, and the remainder of the rack is occupied by the trunk and line relays. A locally made cable form interconnects all relay equipment with the terminal blocks. Figure 7 shows a typical relay rack in detail.

Terminal blocks are provided in the rear of each position for miscellaneous circuits and for terminating battery and ground leads. All position fusing is done at the external racks.

Machine cable for lines and trunks (long and short multiple) is placed on cable pins opposite the jack equipment, and is carried directly to the intermediate distributing frame where the relay equipment is also connected. On small toll boards the jack equipment may be cabled directly to the relay equipment instead of to the T.I.D.F.

TYPE 47—A NEW DESK MONOPHONE FOR MULTI-LINE SERVICE

By M. S. WALLER

SYNOPSIS: *Need for multi-line services — general features of Type 47 Monophone: circuit; keys; click and spark suppressors—ringing arrangements — function and operation of push-keys — push-pull key's many uses: holding; exclusion; external circuit control; buzzer service applications; small business office; executive-secretarial; three-line plan.*

THERE is frequent need in business and professional offices for an arrangement whereby a single compact telephone may be arranged to provide access to any one of two or three lines. The business executive, the purchasing agent, the doctor's receptionist, the secretary, the salesman — these and countless others often have need for telephones of this type.

In addition, such telephones may be expected to add measurably to business efficiency, if they are arranged also to perform one or more of the following functions:

1. Provide for connection to a private branch exchange, as well as to central office lines.
2. Provide for holding a call on one line, while making or answering a call on another line.
3. Provide means of signaling a secretary or other person, without interfering with any telephone conversation which may be in progress.
4. Allow for exclusion and re-connection of an extension telephone at will.
5. Permit connection and disconnection of auxiliary bells, chimes or other signals, as desired.

Typical situations where such services may be needed are: (1) in a suite of offices employing a common reception room and receptionist (such as lawyers', doctors' or salesmen's offices); (2) in a executive-secretary arrangement, where the executive needs access to two lines, with exclusion of the secretary from one line and signaling of the secretary by buzzer; (3) in the office of a "contact-man", who might require access to central office lines as well as to a private communication system.

In the past, such services have often been provided through the use of several separate telephones, or through the use of a single telephone supplemented by auxiliary keys and switching relays. In Automatic Electric Company's new Type 47 Monophone (Figure 1), such services are provided through one telephone of standard size, fitted with built-in switching keys, and without the need for separate key boxes, relays, or lamp signals.

General Features

The Type 47 Monophone, in its physical aspects, is the familiar Type 40 Monophone equipped with push-keys which are mechanically interlocked to provide the special services mentioned above. Since the same handset and circuit components are used in both the Type 40 and Type 47, they have the same transmission characteristics. Also, since the Type 47 housing and base are similar to those of the Type 40, the new Monophone, despite its added usefulness and flexibility, has all of the compactness of the Type 40.

As mentioned before, no auxiliary relays or lamps are required to provide any of the numerous special services. They result entirely from two pairs of push-keys mounted below the dial, and a single, three-position push-pull key mounted above the dial near the right cradle post.

The two pairs of push-keys below the dial are for answering and holding on lines 1 and 2. The push-pull key, depending upon the way it is connected into the circuit, may be used for holding on line 3, excluding an extension telephone, or controlling two independent external circuits. The

Figure 1. Automatic Electric Company's Type 47 Monophone.

external circuits may lead to a loud ringing bell, a visual signal, a buzzer, or any other similar equipment.

A click suppressor in the Type 47 is another desirable improvement over previous key-type telephones. This suppressor greatly reduces the acoustical clicks from the receiver when the user flashes the operator or switches from one line to another. The suppressor is a small dry-disc rectifier which is connected across the "C" and "R" leads of the handset, as shown in Figure 2.

Figure 2 also shows that the pulse springs in the dial of the Type 47 Monophone are equipped with a capacitance-resistance spark suppressor. In the standard Type 40 circuit this spark suppression is provided in the cradle switch circuit, which switches the ringing condenser from the ringing circuit into the pulse-spring suppressor circuit. However, with different lines and ringers connected to the Type 47 Monophone, such an arrangement is no longer possible; the dial is therefore equipped with its own spark suppressor.

Ringing Arrangements

The compactness of the Type 47 Monophone permits mounting only one ringer inside the base. This ringer is connected (at the factory) across the terminals of line 3. However, if desired, the ringer can be transferred to line 1 or 2 by moving the ringer leads to the proper line terminals. The standard Automatic Electric Type 32 Ringer Box is regularly used for providing ringers for the other two lines. Identification of the called line on an incoming call is achieved by use of gongs of different tones. A ringer with small size gongs is used within the Monophone base housing. Standard gongs are used on the ringer in one of the external boxes, and slotted gongs on the ringer in the third box. Ringer boxes equipped with these distinctively toned gongs are available as standard equipment.

Push-Key Control—Lines 1 and 2

The two pairs of push-keys below the dial have their designations engraved on two chromium-plated designation plates (Figure 1). Reading from left to right these designations are "H", "A1", "A2", and "H". The push-keys designated "H" are holding keys, each of which, when depressed, places a 470-ohm holding bridge across the associated line. The keys designated "A1" and "A2" are answering keys; when depressed they connect the talking circuit to line 1 or 2, respectively.

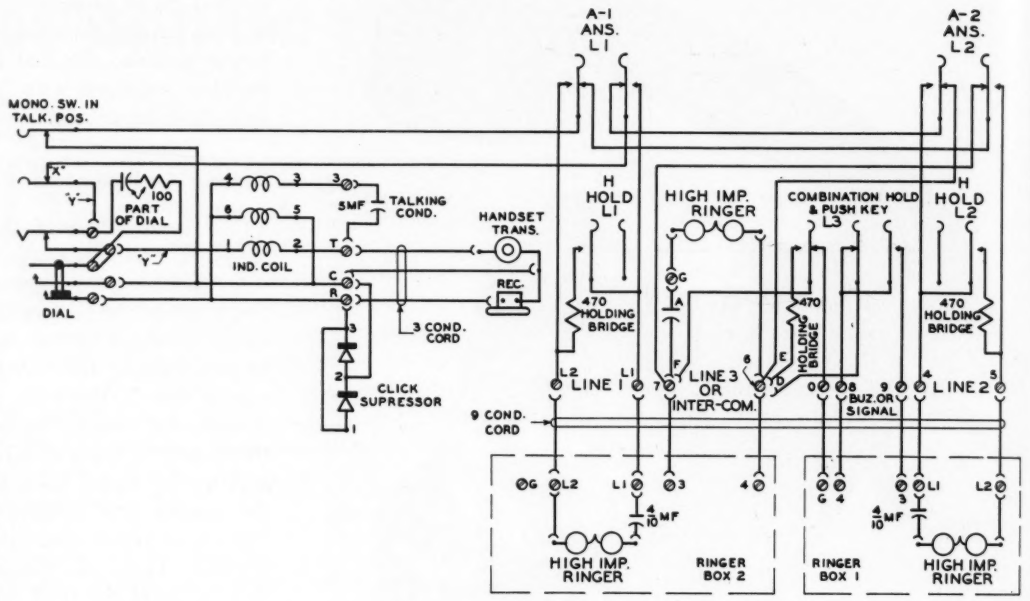


Figure 2. Circuit Diagram of Type 47 Monophone.

The "H" ("hold") and "A" ("answer") keys of each pair are mechanically linked so that both in the pair may not be operated at the same time. Thus operation of the "hold" key automatically restores the "answer" key, and vice versa. Restoration of the "hold" key removes the 470-ohm holding bridge from the line. (If this bridge remained on the line after the answer key was depressed, transmission would be greatly impaired.)

The two "answer" keys—one for each line—are also mechanically linked so that both may not be operated simultaneously, so that conflict of the two lines is prevented. Thus, if "A1" is in a down position when "A2" is depressed, "A1" will automatically be restored to normal. However, if it is desired to hold line 1 and switch to line 2, the "H" key for line 1 must be depressed before the answering key "A2" is depressed. Failure to do this will cause the call on line 1 to be cut off. Of course, the same is true in switching from line 2 to line 1.

The two hold keys are also mechanically linked to the right-hand cradle-switch plunger. This plunger is finished in black to distinguish it from the left-hand plunger, which is chromium-plated. When the right-hand (black) plunger is depressed, either directly or by replacing the handset, all of the hold keys are automatically restored to normal. This arrangement prevents any line from being held unintentionally when the handset is restored. The left-hand (chromium-plated) plunger operates only the cradle switch. Thus, it provides a means for flashing the operator without affecting the position of any of the push-keys, and a means of obtaining dial tone again in case of an error in dialing.

Push-Pull Key Has Many Uses

The push-pull key near the right-hand cradle post has three positions: "normal", "up" and "down". When the key is lifted to the "up" position it will lock there until it is manually re-

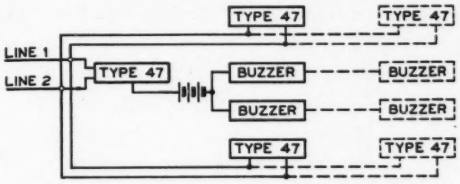


Figure 3. The Type 47 Monophone in a Small Business Office Arrangement.

stored, or until the right (black) cradle plunger is depressed, either directly or by replacement of the handset. (Depression of the cradle plunger restores the key to its normal position by means of a mechanical link, just as the other hold keys are restored.) When the key is depressed to its "down" position it will automatically return to its normal position when the depressing force is removed; that is, it is non-locking.

The three-position push-pull key can be wired to give any of several different services. If the Monophone is used for three-line service, the key may be wired to place a 470-ohm holding bridge on line 3 in its "up" position. If the Monophone is used for two line service, and there is an extension telephone on one of those lines, the key and connection to the extension telephone may be wired so that the extension is excluded from the line when the key is lifted. When the push-pull key is used neither for third line service nor exclusion of an extension telephone in its "up" position, it may be wired for opening and closing the circuit to an auxiliary signal, such as a loud ringing bell. If it is desired that this auxiliary circuit be unaffected when the handset is restored, the mechanical link between the right cradle plunger and the push-pull key can be disabled

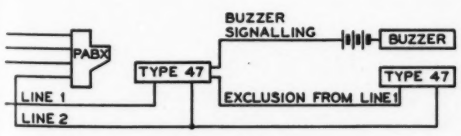


Figure 4. Executive-Secretarial Plan with the Type 47 Monophone.

to provide this arrangement. This disablement is accomplished by clipping the small pin in the shaft of the push-pull key. With the pin cut, the push-pull key must be restored manually. The external circuit may be opened and closed as desired, without interference with or by other controls.

When the three-position key is depressed to its "down" position, it closes a pair of "make" springs which may be used for closing a separate circuit to any external device as, for example, a secretarial buzzer. (It is to be noted that third-line holding or extension-telephone exclusion cannot be provided during depression of the key.) When the depressing force is removed from the key, it will be restored to its normal position by the tension in the springs against which it operates.

Service Applications

Typical applications of the Type 47 Monophone are shown in Figures 3, 4 and 5. Figure 3

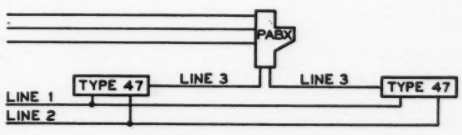


Figure 5. The Type 47 Monophone in a Typical Three-Line Service Plan.

illustrates use of this telephone in a typical small business office. Two central office lines are multipled to two or more Type 47's, as desired. These telephones may be used for answering or holding on either of the lines. One telephone—let us say the receptionist's or secretary's—may be arranged so that depression of the push-pull key will indicate to the users of the other telephones that a call is to be picked up. Signaling codes may be used to indicate persons and lines.

Figure 4 shows a typical executive-secretarial plan. Two lines are connected directly to the executive's telephone. These lines may be central office lines or private branch exchange lines, or one line of each type. The secretary's telephone is arranged for answering on either line, but since line 1 to the secretary's telephone is connected

through the executive's telephone, he may exclude the secretary from line 1 by lifting the push-pull key. Also, as an added convenience, the executive may signal his secretary by depressing the push-pull key which closes the buzzer-signal circuit.

Figure 5 shows a typical three-line service plan. Two central office lines are multipled to two or more Type 47's. Users of these telephones may answer and hold on either of the lines. The third line is connected to a P-A-B-X for internal communication. Holding on the third line is also possible through operation of the push-pull key to its "upper" position.

These three plans are merely representative of the many combinations of services which the Type 47 Monophone can provide, and many others will readily occur to the operating or commercial manager of the telephone company with specific reference to the needs of its own customers. In making the Type 47 Monophone available to the telephone industry, Automatic Electric Company believes that the design not only makes provision for a greater variety of services than is offered by older types of key telephones, but also provides these services in a more efficient and convenient manner than has heretofore been possible.

PAYSTATION SERVICE FOR MANUAL AND AUTOMATIC TELEPHONE SYSTEMS

By M. E. GRIFFINS

SYNOPSIS: *Historical—post-pay and pre-pay coin collectors—supervisory and identification facilities—toll call equipment—service for branch offices—comparison of Automatic Electric and Bell System practices—the Autelco Gray Paystation as a standard.*

BECAUSE telephone exchanges differ so widely with respect to operating conditions and types of central office equipment, the development of telephones for public paystation service has resulted in a wide variety of types to meet different technical and commercial requirements.

In general physical design, the paystation telephone has settled down to a stage of reasonable and practical standardization. With respect to detail and methods of application and operation, it presents a seemingly complex array of combinations with the result that the operating executive may sometimes lack a clear understanding of the differences between them and of such facts as would enable him to make the best choice for the needs of his own exchange. It is thought, therefore, that a discussion here of modern paystation techniques would be of some help in guiding telephone companies in planning facilities for this important phase of their service.

Early History

Modern paystation service was slow in establishing itself in the telephone industry, even though today it accounts for a substantial portion of operating income. The Bell System reports that about seven per cent of its operating revenue comes from paystations. Paystations should, of course, be equally productive for many Independent operating companies.

William Gray, founder of the Gray Telephone Paystation Company, invented the paystation in 1889, but it was not accepted commercially until ten years later. In fact, Mr. Gray found it necessary to install paystations on a commission basis until public approval made it economical for the telephone operating companies to own the station equipment. Improvements in design made during this trial period are still basic in present-day coin boxes.

Post-Pay Coin Collectors: Two Types

The simplest type of paystation is the manually supervised coin collector for post-pay operation. The user completes a call as if from a regular telephone. Then, on the operator's instruction, he deposits a coin in the proper chute, which checks it for size and directs it into the coin box. In passing through the chute (see Figure 1) the coin strikes a gong, whose vibrations are extended mechanically to the back of the telephone transmitter to make the sound audible to the operator. Multi-slot stations have a separate chute for each coin size, together with different sounding gongs. This type of paystation is still widely used in manual systems, and even in automatic systems in those cases where practically all the originating calls are toll and there is no charge for local calls. Such simple coin collectors for manually controlled post-pay operation are well known, and require no further description.

Automatic Electric Company adapted the coin collector to automatic post-pay operation by using relays for supervising coin deposits on completed local calls (but retaining manual supervision of coin deposits on toll calls). Two types have been developed, each permitting the call to be completed, but blocking effective speech from the calling station on local calls until a coin is deposited.

Semi-Post-Pay Type

The first type, developed in 1910 and regularly supplied by Automatic Electric Company, is known as *semi-post-pay* (reverse battery). In this type of equipment, all control equipment is mounted within the paystation box.

When a local number is dialed from the paystation, equipment at the central office reverses the direction of current on the line. This current reversal operates a mechanism at the paystation which blocks speech transmission; when a coin is deposited, the mechanism releases the block and allows transmission for the duration of the call.

When a toll call is made, however (or any non-local call, such as information, etc.), reversal of line current does not take place; transmission is thus possible without the coin deposit, since there is no transmission block to be released. The calling party can thus reach the operator and give his order without depositing a coin.

The reverse battery type of paystation can be used without equipment changes in most Strowger-type central offices (such as those manufactured by Automatic Electric Company). This type is not normally used in manual systems, however, since manual switchboards are usually not arranged to extend answering supervision to the calling line.

A simplified diagram of the control equipment for this type of paystation is shown in Figure 2. The equipment consists of a relay mechanism which has two polarized magnet coils—one low-resistance, the other high-resistance—and three sets of mechanical-latching-type spring combinations. When a local call is answered, the current on the calling line is reversed; this energizes the low resistance coil (P_1), which operates two sets of the spring combinations (A and C). One set of springs (A) places a shunt across the calling station transmitter, but does not block the receiver; the second set of springs (C) bridges the high-resistance coil (P_2) across the line (the latter coil does not function at this time, however, since it is shunted by the operated hook switch springs). The transmitter shunt is cleared when a coin, in dropping through the chute, strikes a spring mechanism that releases the transmitter shunt springs (A) At the same time, the coin-operated springs (B) short-circuit the low-resistance coil (P_1), preventing the transmitter shunt springs (A) from re-operating on any subsequent current reversals during that call. When the calling party disconnects, the central office equipment releases, restoring the normal polarity of the line. Opening of the hook switch springs also removes the shunt across the high resistance coil (P_2), which operates on the normal line current and restores all springs—including those that disconnect the coil (P_1) from the line.

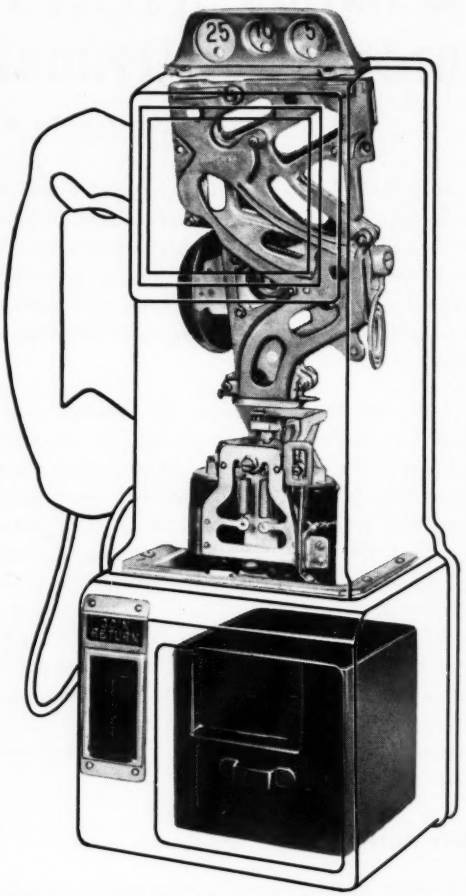


Figure 1. View of Paystation Coin Mechanism Showing Coin Chutes and Collection Box.

Marginal Relay Type

The second type of post-pay automatic paystation, developed by Automatic Electric Com-

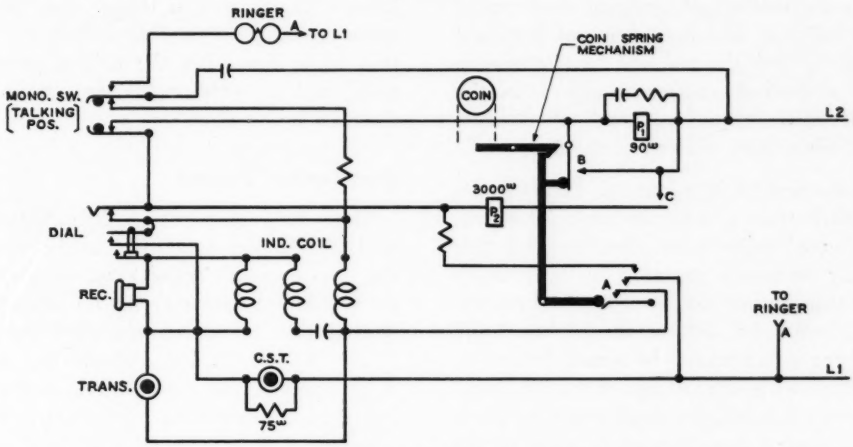


Figure 2. Schematic Diagram of Semi-Post-Pay (Reverse Battery) Paystation Circuit.

pany in 1918 and later used by the Bell System, also requires reverse-current control at the central office. The control relays for the paystation, however, are mounted in the central office instead of at the paystation. In this so-called *marginal relay* type, the transmission-blocking relay releases when a marginal line condition is momentarily established by the deposit of a coin. This is explained by the fact that reversal of current on answer by the called party operates a polarized relay which opens the talking circuit, extends a tone to the calling station, and connects the line supervisory relays. A deposited coin, in passing through the coin chute, strikes a spring that momentarily inserts a high resistance in the line and restores a marginal line-supervisory relay previously connected when the polarized relay operated. Auxiliary relays then operate, re-establish the transmission circuit, and lock out the polarized relay. Release is effected when the calling party releases the central office equipment. This type of paystation telephone has been adapted to answering supervision on switchboards of various makes which do not provide for reverse current supervision.

Pre-Pay Coin Collectors

Prior to 1910 all paystation service was based on post-pay operation. As telephone toll business expanded, however, a demand for a more efficient method of collecting toll charges from paystation resulted in the introduction of *pre-pay operation*. This scheme requires that coins be deposited before a call is extended; no holding of the toll connection is therefore necessary—no delay caused by collection of charges. Deposited coins are refunded on incompleted calls. Pre-pay coin boxes are designed to keep the deposited coins suspended below the coin chute on a platform controlled by a polarized relay. Depending on the polarity of a high-voltage coin current sent over the line, the coins are directed either into a refund chute or into the coin box.

The Gray pre-pay type of paystation, a combined telephone and coin box, became standard with the Bell System in 1912. A similar unit for either post-pay or pre-pay operation was available to the Independent telephone companies by 1921; it was adapted to automatic operation by Automatic Electric Company in cooperation with what was then the Gray Paystation Manufacturing Company.

Special Equipment Required

Pre-pay service requires special central office equipment consisting of separate 90-110V — and + coin-control current supply, special trunk circuits, and coin-control facilities in the connecting manual switchboards. In manual pre-

pay service lines, the trunk or line equipment varies with the method of applying coin-control current on different boards, and is not described here. However, both the toll and local operators must have a clear direct-current path from the jack to the station, or else the trunk circuit must extend the coin-control current to the line.

For pre-pay service in automatic exchanges, a separate switch train is generally used. This consists of standard primary switches, first selectors with pre-pay paystation repeaters in the primary trunk, and coin-control combined line and recording (CLR) trunks. In addition, the toll board and toll completing switches must be arranged for coin control. The latter feature is part of the toll transmission selector switch that extends a direct-current trunk to paystation line through a train of toll switches. Connectors are arranged to switch through on toll calls, transferring the transmission current supply from the connectors to the toll transmission switch where it can easily be bypassed for coin control.

Another feature provided in standard coin CLR and toll switches is *re-ring*, which permits resignaling the paystation immediately, to collect additional overtime charges. This feature is important when the (preferred) practice of allowing the station to complete a call without interruption is followed. (This last feature is also applicable to post-pay operation.)

Coin Chute and Mechanism

The paystation telephone operates in the same way as a regular station, except that the central office paystation trunk equipment blocks each call. In automatic operation, the accepted practice is to short-circuit the dial pulse springs at the telephone and at the trunk circuit (the latter also blocks dial tone). A deposited coin, in passing through the chute, operates a latching spring mechanism that clears the short circuit across the dial pulse springs and connects the coin-control relay coil to the + or *tip* side of the line. The other side of the coil is connected to ground. This coil unbalances the line through its 1,020-ohm resistance, but since there is high impedance at voice frequencies the interference with transmission is not noticeable. The direct-current line unbalance operates a line differential relay and auxiliary relays in the trunk circuit, which registers the unbalance at the central office. This prepares the trunk circuit for extending a call, for automatic coin controlling after the calling person disconnects, and for holding the line equipment until the coin box is clear.

Coin-Control Current

After the calling person disconnects, pulses of 90-110V coin control current are connected to the line: — current (collect) on an answered call, or + current (refund) on an unanswered call. The polarity of the coin-control current determines the direction in which the coin-control relay operates the coin-control mechanism. The operation of the control relay requires 65-70 milliamperes of direct current, and it is not affected by normal line current. The coin-control mechanism operated by the control relay releases the suspended coins into the "refund" or the "collect" portion of the coin chute, and at the end of the coin current pulse, releases the control relay latching spring, and clears the unbalanced line condition; the central office equipment then releases. If the coin mechanism does not operate on the first pulse of coin-control current, successive pulses are sent until the line is clear. A switchroom alarm is sounded if the line is not clear within a definite time interval.

On a toll call, the trunk circuit operates as on a regular answered call, extending a direct-current path from the toll board to the station. The standard *CLR* trunk (coin-type) automatically refunds the initial deposit. All subsequent coin depositing, collecting, or refunding is under the direct supervision of the operator. These operations may be completed before the calling party disconnects. The coin-control current is extended over both line conductors in parallel, so as to reduce the potential across the receiver and avoid severe acoustic shock if the calling party is on the line.

The coin control, provided by a key in Automatic Electric Company toll boards, is common to all cord circuits in the position and is extended over the *T* and *R* conductors of the jack after the line is cleared. When the transmission battery feed is in a separate trunk circuit, such as in a branch office, Automatic Electric Company practice is to extend coin control current over the regular line

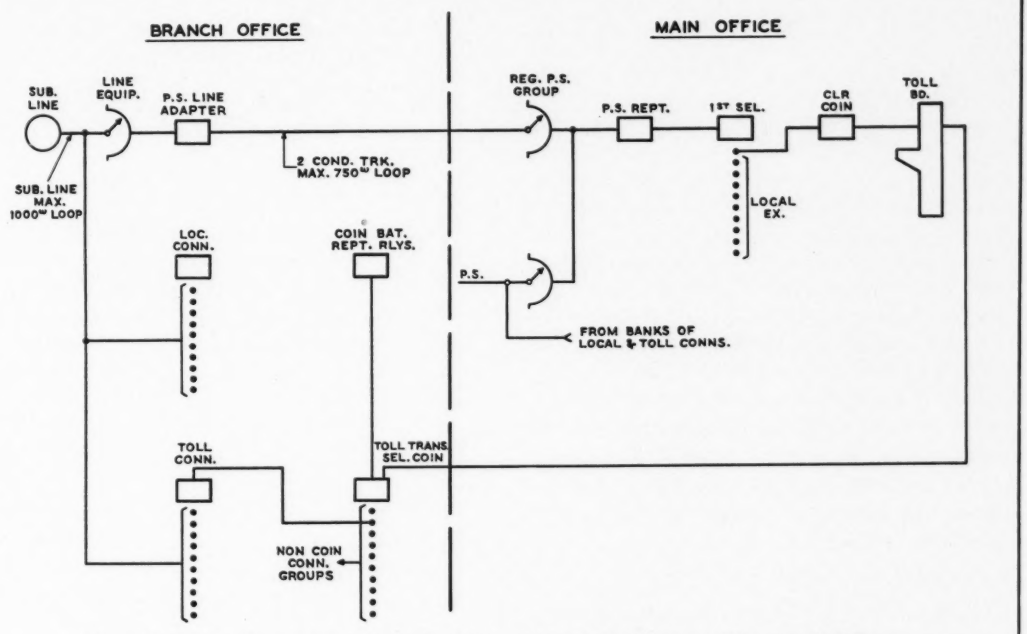


Figure 3. Trunking Arrangement for Pre-Pay Service, Using Line Adapters at the Branch Office.

conductors. The same toll board coin-control equipment is used on toll-switching trunks for delayed or reversed-charge calls.

Operating Specifications

Operating limits of paystation lines are the same as the regular exchange line limits. In 48-volt exchanges where the maximum 1,000-ohm subscribers' loops are standard, the coin current supply must be at least 110 volts; on shorter loops, 90 is the minimum. Branch office coin-control *CLR* and toll switching equipment must include coin-repeating facilities if the maximum station loop is used. Otherwise, allowances for the interoffice coin-control conductor must be deducted from the station loop. If separate coin conductors are used, the coin trunk plus one-half of the paystation line loop must not be greater than 500 ohms. When Automatic Electric Company standards are applicable, the coin-control current is extended over both conductors of an interoffice trunk; the maximum 500-ohm line conductors can be approximately one-third of the trunk loop plus one-half of the station line. These limitations in trunk loop do not apply to post-pay station operation as such service is provided over the regular trunk circuits.

Line Adapters

In multi-office automatic areas, special equipment is available for service to a few outlying pre-pay service lines, where a separate switch train is not justified. A line adapter at the intermediate exchange permits operation of a long paystation line as a terminal in the main office paystation group. This equipment repeats all the coin ringing and dialing operations and feeds transmission current. The only other special equipment required at the branch office is a coin-control current supply. Of course, a trunk pair is required for terminating each of such lines on a main office paystation line circuit.

Another arrangement for a group of pre-pay service lines in a branch office is to use concentration primary switches with a common group of adapters in the trunks terminating directly on the main office paystation line circuits (as shown in Figure 3). In this case, the line circuit is in

the main office, but the connector terminals must be assigned in the branch office. A toll train arranged for coin control must also be provided at the branch office. These arrangements are practical if the pre-pay service lines have a high toll usage, since the separate group of interoffice *CLR* trunks is not required. In either case, local calls to the branch office are first terminated at the main office and routed back to the branch over the regular interoffice trunks.

Still another type of line adapter is available for a few pre-pay service lines in a tributary office. This type combines the operation of the trunk circuit and *CLR* trunk, including automatic refund on toll calls (digit 0) and coin control. Manual control of collect and refund is provided by operator dialing of separate connector terminals. This circuit will operate over regular tributary trunks. The only other special equipment is the coin-current supply.

Post-pay service lines do not require any special trunk equipment for branch office operation. However, it is desirable that the regular *CLR* trunks be arranged for re-ring and class-of-service tone.

Call Identification Methods

Paystation service calls must be easily identified by the *CLR* toll operator. In pre-pay operation, the separate group of trunks provides suitable identification. In addition, many Independents are following the Bell System practice of assigning paystations in the *9000* group, or using *9* as the first of the station digits by means of a multiple from the ninth level to another thousand if the *9000* group is not equipped. On post-pay automatic service or in common tributary trunks, Automatic Electric's standard tone identification has been acceptable to all operating companies. When an operator answers, she hears a spurt of tone. This tone is connected to the control (*C* or *sleeve*) lead through a small condenser at the line circuit. The tone is transferred to the trunk talking conductors through a transformer coupling, for a time interval after the operator answers. The operator can reconnect the tone if she wishes.

Paystation and Operating Companies

It is a general practice for the telephone company to provide paystation service under an arrangement whereby the owner of each paystation location is paid a percentage of the paystation revenue.

Message register facilities can be provided in most automatic systems. Automatic Electric Company trunk adapters provide optional wiring for this service, and a message-rate line relay is available for post-pay lines. In either case, a message register is required for each paystation line.

The Autelco-Gray Paystation, now manufactured by Automatic Electric Company, is the standard for Independent operating companies in the United States and many other countries. Standard units are designed for each type of paystation service. High quality transmission is assured, because transmission components are the same as those used in non-paystation equipment.

For the convenience of operating companies that have standardized on telephone instruments of a particular manufacturer, adapters are available which make it possible to use the transmission components of such instruments in the standard coin box. There are also post-pay coin boxes available for use with existing telephones modified by small wiring change.

The paystation service and equipment most suited to the requirements of each local community, together with the number of stations and anticipated revenue, should be carefully considered when paystation service is introduced or when the telephone system is changed from manual to automatic. No general recommendations can be given, but it is clear that there is a definite preference for pre-pay service in metropolitan areas and in those areas where there is a high paystation calling rate from a transient population. Many state commissions, also, have indicated that they prefer pre-pay service. In more stabilized communities, and particularly in tributary offices, post-pay service is satisfactory.

CARRIER-CURRENT PULSING OVER TOLL TELEPHONE CIRCUITS

By IMRE MOLNAR

SYNOPSIS: *Techniques in communication—pulsing methods in toll operation — voice-frequency signaling — composite pulsing — carrier channel signaling methods—establishing the carrier toll connection — the three channel carrier system — equipment requirements—carrier pulsing circuit operation — dialing performance — distortion — signaling range — interference—automatic bias control—applications of toll dialing systems—early public toll dialing.*

NO matter what medium is used to transmit intelligence between two points—whether it consists of writing a letter, sending a telegram, or making a telephone call—two fundamental objectives are common to all of them. One is that the "addressee" of the message must be sought out and reached; the other is that the message itself must be intelligibly transmitted.

Conforming to this dual aim, communication engineering concerns itself with two distinct kinds of techniques. There are, first, the techniques by which the path to the "addressee" is selected and made ready to receive the message; second, there are the techniques by which the message is transmitted over that path. In the following discussion we are concerned only with the former techniques, and specifically with their application to carrier telephone channels.

Generally speaking, a telephone connection can be established by the intermediary of one or more operators, by the substitution of remotely controlled switching equipment for the operators, or by a combination of both methods. Since telephone connections now extend over unlimited distances and increasingly complex routes, the individual path chosen can no longer be identified. Accordingly, universal operating procedures are necessary: the same standard procedure must apply in all cases, irrespective of the transmission medium —open wire, cable, carrier or radio—which is employed.

Because of their advantages in line plant economy and in quality of transmission, carrier systems today form the backbone of the nation's long distance telephone network, as well as of a large number of systems used by service organizations such as railroads, power utilities and pipelines. Consequently, the problem of signaling through, and switching of, carrier circuits is of the greatest importance.

Pulsing Method in Toll Operation

Whenever connections are established by automatic switching equipment, there exists the problem of transmitting certain signals over whatever type of circuit is employed. Although it is often assumed that all conditions for automatic operation are fulfilled simply by assuring that pulses can be satisfactorily transmitted, it is also necessary at times to transmit a large number of signals in one direction or the other. There are a number of satisfactory toll dialing systems in operation, although this article will mention only two of them.

One of these methods is called "voice-frequency signaling", because the signals used consist of short applications of voice-frequency current to the voice-frequency terminals of the talking channel. In a telephone circuit, because a speech path exists from one end to the other, a signal path is provided automatically as long as voice frequencies are used for signaling. And since speech transmission is maintained at a satisfactory level and quality over unlimited circuit lengths, a satisfactory signal level and quality are automatically maintained without additional provisions. The various signals are distinguished from one another

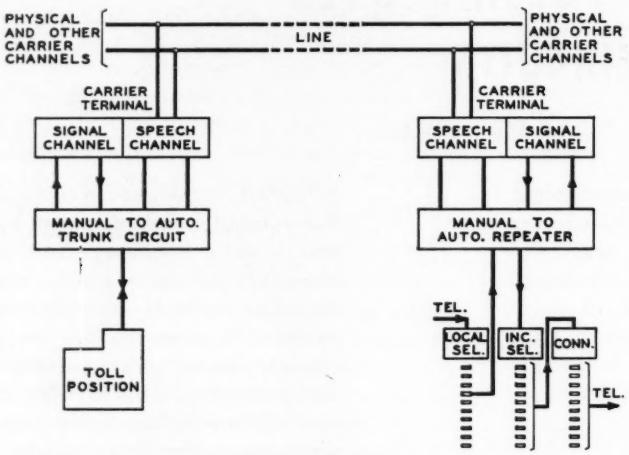


Figure 1—Signaling System Schematic Diagram.

by their sequence, direction of transmission, frequency, timing, and modulation.

Although its theory is sound and attractive, voice-frequency pulsing presents inherent difficulties which make it about the most intricate problem in the whole art of automatic control. While most of these difficulties may be met by proper circuit design, every such step results in a considerable increase in cost.

Voice-frequency pulsing is useful on long and complex circuits, which include one or more carrier links (not necessarily of the same system), and which are operated from end to end on a voice-frequency signaling basis. In many instances, however, inexpensive carrier systems are installed because of their economy on relatively short-haul toll lines. Since a properly designed terminal for voice frequency signaling is quite costly, its use may defeat the economy of carrier installation on such circuits. Although voice-frequency dialing is widely and effectively used over all types of circuits, a much simpler, less costly and even more efficient system for carrier operation has been developed jointly by Automatic Electric Company and Lenkurt Electric Company.

Another method of long distance pulsing employs direct current exclusively. There are several types in operation, probably the most useful of which is known as "composite" pulsing. With suitable networks of chokes and condensers, it is possible to send direct-current signals independently over each wire of a pair, without mutual interference with speech simultaneously present on the same pair. It is possible, furthermore, to arrange these composite circuits for duplex operation: that is, for signaling simultaneously in both directions over the same conductor. In spite of its excellent performance, however, composite pulsing also has its limitations. One is that d-c signals must have a d-c path, which is seldom available in carrier operation, and never on radio circuits. Furthermore, a three-channel carrier system provides four speech circuits (including the physical) over one pair of wires, while the maximum in d-c operation is two duplex composite signaling channels on the pair, leaving two speech channels without means of signaling.

From the standpoint of circuit technique, nothing could be simpler and more straightforward than d-c signaling. Practically all signals for toll or straight automatic operation can be provided by the application and removal of a d-c potential. This becomes particularly simple if a reliable duplex system or separate signaling channels are available for either direction. With a few exceptions the signals are independent of any timing or sequence, and the marginal conditions are even less exacting than in ordinary local operation. This makes it apparent that the most suitable pulsing method in carrier operation is one which duplicates d-c signaling by means which permit the passage of signals through carrier circuits. For instance, two independent frequencies, one for each direction within the transmission band of the system, can be applied exactly as in d-c operation. If the signal frequencies are located within the transmission band of the carrier system, but outside of the intelligence sidebands, they will travel the whole distance together with speech trans-

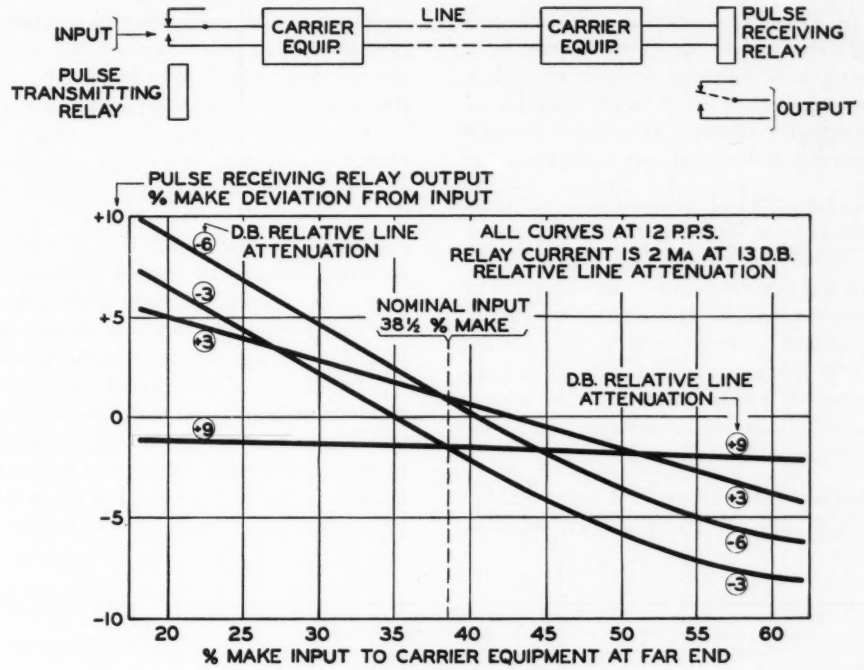


Figure 2—Pulsing Characteristics.

mission without being subjected to mutual interference in the final demodulation process. The boundary conditions are particularly simple: there is a 1:1 correspondence of direct to alternating current at the sending terminal, and back again at the receiver.

There are several ways to provide such a circuit. If there is a surplus frequency band beyond what is needed for the speech channels, it can be divided into a number of narrow bands, with two of these assigned to each channel for signaling in either direction. While this is a practical method and is used to some extent, it is also wasteful, because the signaling channels extend the total band width upwards, and the surplus frequency spectrum could be more usefully employed for additional speech channels.

A far more efficient method is to exploit the channel carrier frequency for signaling purposes, since it is suppressed in single sideband operation as far as voice transmission is concerned. In the system frequency spectrum there is a separation between sidebands comprising adjacent channels varying between 600 and 1300 cycles, and also a 250-cycle separation between each sideband and its associated carrier. This space can now be utilized for signal transmission. The signal channels thus take advantage of the frequency bands which would otherwise be wasted, and make use of the existing carrier frequency supply instead of separate signal frequency oscillators.

Establishing A Toll Connection Over Carrier Circuits

As a typical example, let us consider a connection between a manually operated toll center and a distant automatic network.

Figure 1 shows a schematic layout of a carrier toll connection. The carrier terminal (left) is connected to the toll board jacks through a special manual-to-automatic trunk circuit. The interconnection between the trunk circuit and the carrier

terminal apparatus consists of a pair of talking conductors and two signaling leads—one for each direction. A Strowger Automatic telephone exchange (right) is tied to the carrier system by a manual-to-automatic two-way repeater through a like number of conductors. A block diagram of the carrier signaling channel, and curves showing its transmission performance, appear in Figure 2.

To reach a subscriber at the automatic exchange, the toll operator first inserts a plug into the jack of an idle carrier channel, placing direct-current potential on the signaling lead in the direction of the automatic exchange. This causes the carrier frequency signal to be transmitted. At the receiving end the carrier frequency signal is selected, amplified and detected, which establishes a d-c circuit to the manual-to-automatic repeater, ready for seizure of the automatic equipment.

The operator now sends several series of dial pulses corresponding to the requested number. These pulses, consisting of interruptions of the steady potential, are set at an approximate rate of 10 per second, one interruption occupying 61½ percent of each pulse cycle. In the automatic exchange these pulses, after being reconverted into direct current, alternately energize and deenergize ratchet-driven devices (switches) which extend the circuit step-by-step to a set of contacts to which the called subscriber's telephone line is connected.

The line is now tested. If it is free, it is automatically signaled by ringing current; if it is engaged, the operator receives a busy signal. When the called subscriber answers, a d-c potential is placed on the signaling lead in the direction of the toll board. Upon receipt and detection it causes the carrier-frequency signal to be transmitted, which extinguishes the called-end supervisory lamp in the cord circuit. When the called subscriber hangs up, the d-c potential is removed and the supervisory lamp again glows. If the operator's

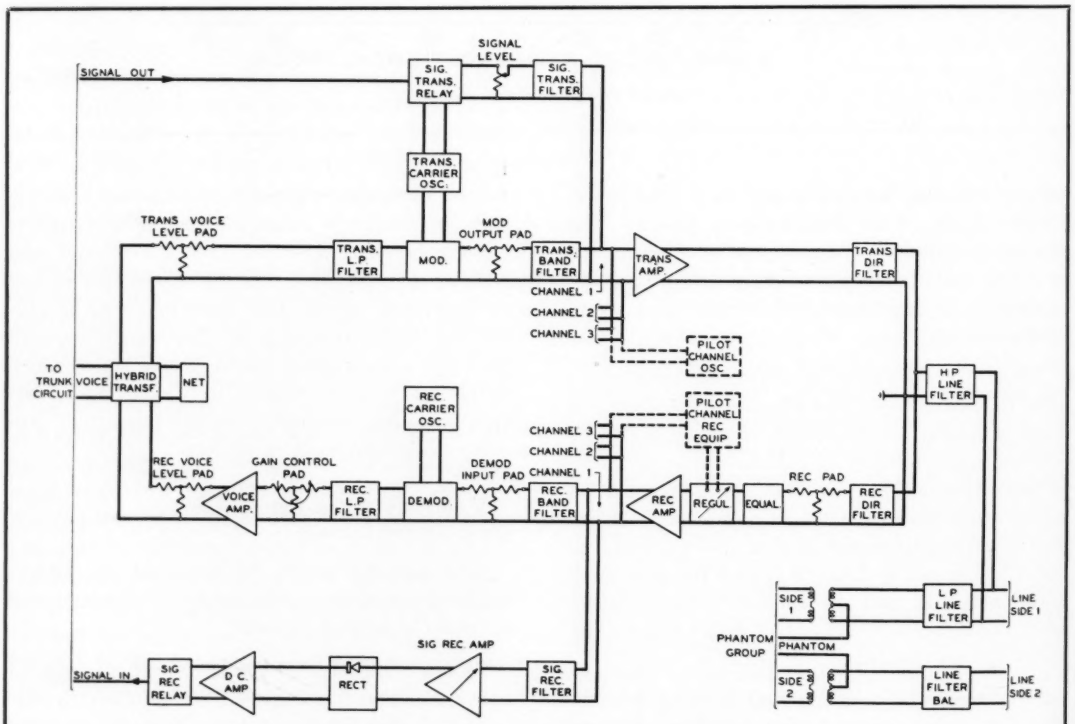


Figure 3—Carrier Terminal Schematic Diagram.

local subscriber has disconnected in the meantime, the operator removes the plug, thereby removing the potential from the signaling lead. The corresponding potential at the automatic terminal also disappears, and all switches there return to their normal position.

When a call originates at the automatic exchange, the calling subscriber dials the number of the distant toll board. The switches in the local office operate under the subscriber's control and automatically seize an idle carrier circuit through its manual-to-automatic repeater. The same d-c potential as before is placed on the signal lead, and carrier-frequency current is transmitted. After being selected, amplified and detected, the carrier signals appear as d-c signals and the line lamp associated with the carrier trunk glows at the toll switchboard. An operator plugs in, extinguishing the line lamp, and places a d-c potential on the signal lead towards the automatic exchange. After receiving the number request, the operator completes the connection locally.

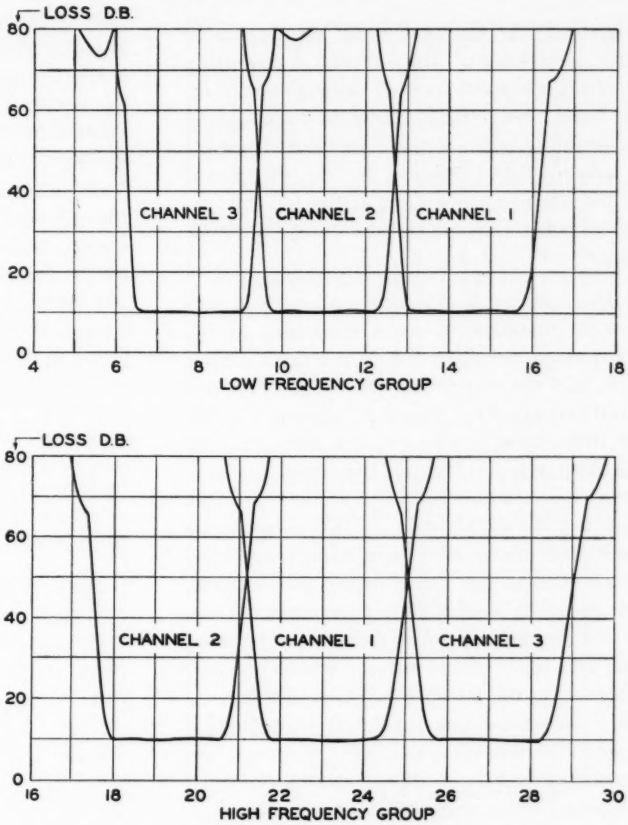


Figure 4—Band Filter Attenuation Characteristics.

When the calling subscriber hangs up, the signaling potential is removed, and the calling-end supervisory lamp in the cord circuit glows. When the operator removes the plug from the carrier-circuit jack, the potential towards the automatic exchange is removed, and the toll circuit is again available for a new call in either direction. Whether the local equipment in the automatic exchange is held operated during the period between the calling subscriber's disconnect and the operator's taking down of the connection, or is released as soon as the calling subscriber hangs up, is optional: each practice has points in its favor. These are typical procedures for the simplest connections.

Three-Channel Carrier System

Figure 3 is a schematic diagram of the Lenkurt Type 32 three-channel carrier telephone system, which is widely used in automatic toll operation. The meeting point between the carrier equipment and the individual local voice-frequency physical circuits is the hybrid network. The transmitting branch of the four-wire circuit consists of the transmitting low-pass filter for attenuating the voice frequencies above the desired pass-band, the modulator, the output filter for passing the selected sideband only, and the transmitting amplifier. The receiving branch includes the demodulator, the

receiving low-pass filter and the receiving amplifier.

Disregarding for the time being the associated signaling equipment, the three transmitting branches are grouped together through their receiving band filters. Each group is amplified by the transmitting and receiving amplifiers, respectively, and further combined by the directional filters. The high-low-pass filter at the toll line entrance segregates the carrier band from the physical circuit.

The line current is a complex mixture of frequencies. It includes the voice frequency of the physical circuit, the sidebands of the three carrier channels, and the carrier frequencies proper when employed for signaling. About 30 kilocycles is the highest transmitted frequency on a three-channel system. Each repeater section may have up to a 43-decibel line attenuation at 27 kc, and can furnish a 0 loss circuit between the voice frequency terminals with the usual transmitting input level of 18 db above the transmitting switchboard. This attenuation would limit a repeater section of 114-mil copper wire to a distance of between 125 and 300 miles under adverse weather conditions. However, the distance can be somewhat increased if automatic gain regulating equipment is employed. The transmission range, of course, can be further extended to almost any distance by intermediate carrier repeaters.

The success of carrier dialing depends entirely on success in reproducing sharp pass-band filters which: (1) keep the speech sidebands out of the signal channels; (2) keep the carrier frequency out of the speech channel; (3) reproduce with little distortion important sidebands of the signal current. In addition, systems having filters of such well defined characteristics also require well balanced modulators, and stable oscillators for permanent centering of the carrier frequency inside the filter pass-band. A 10-cycle deviation between modulating and demodulating frequencies is about the limit of tolerance; during system lineup these frequencies can be adjusted to within ± 2 cycles. The components which meet these requirements must be economical to manufacture, since low cost frequently determines the installation of carrier systems.

Figure 4 shows the characteristics of typical transmitting and receiving band filters. They are substantially flat in the passband, and in every case the attenuation is better than 60 db between adjacent channels in one terminal. The amount is actually doubled, since there are identical transmitting and receiving pass-band filters at both ends of the circuit. Although there may be a difference of 43 db in the levels of the transmitting and receiving paths, crosstalk between them at the same terminal is negligible. Their wide frequency separation and the directional filters between the transmitting and receiving amplifiers also help prevent crosstalk. The net result is equivalent to what is known as "near-end crosstalk" in physical circuits.

Figure 5 shows the characteristics of typical signal receiving and transmitting filters. Sharp signal receiving filters are essential for satisfactory pulsing performance because the selectivity of the signal receivers against the arriving complex frequency mixture depends entirely upon them.

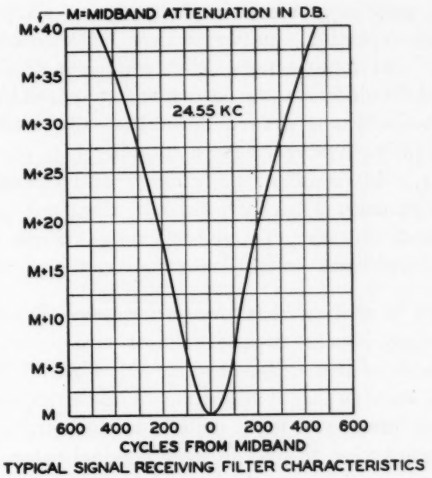
Figure 6 shows the stability of a typical carrier oscillator over a temperature range of 30 to 120 degrees F. Within this range there may be a variation of $\pm 1\frac{1}{2}$ cycles. If the filament and plate voltages applied to the oscillator tube circuit change simultaneously by 25 percent, the frequency will not change more than ± 1 cycle. There may be a like amount of random variation upon inserting any one of 20 commercial 6N7 tubes in the oscillator circuit.

Carrier Pulsing Circuit Operation

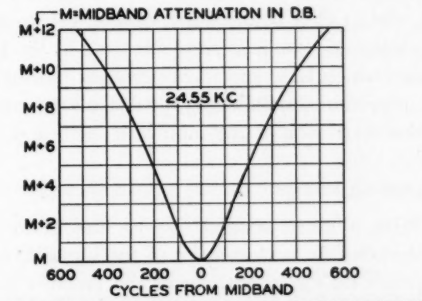
Figure 7 is a circuit diagram showing one version of a signaling terminal. The d-c potential which is placed on the signaling lead at the switching equipment operates the pulse-transmitting relay in the terminal. The contacts of this relay apply the carrier frequency source, through a signal transmitting pad and the narrow-band signal transmitting filter, to the transmitting circuit common to all speech and signal channels. The carrier frequency signal is interrupted by the pulse-transmitting relay contacts while dial pulses are sent, at the rate and ratio specified below.

At the distant terminal the incoming signaling frequencies enter the signal receiving channel unit through the narrow-band signal receiving filter. This selects the proper signaling frequency for its particular channel out of the complex mixture of

several carrier signals and speech sidebands. The signal then passes through a two-stage resistance-coupled amplifier, the output of which is transformer-coupled to a germanium diode. The rectified signal voltage is connected to the grid of a relay tube. Since the rectified voltage is negative with respect to the cathode, the plate current of the relay tube is reduced on receipt of carrier signal, causing the normally energized receiving relay to release and to connect a marking potential through its contacts to the signaling lead to the switching equipment. The signal receiving relay follows the interruptions of the carrier signal during dialing, and reproduces these pulses in the form of interrupted direct current over the signal lead and the manual-to-automatic repeater to the switching equipment. The operation of the signal receiver is further discussed in the sections on signaling range and interference.



TYPICAL SIGNAL RECEIVING FILTER CHARACTERISTICS



TYPICAL SIGNAL TRANSMITTING FILTER CHARACTERISTICS

Figure 5—Signal Filter Characteristics.

Dialing Performance

Specifications for automatic telephone equipment call for a pulsing speed of 8 to 12 pulses per second, and an exchange voltage held within ± 10 per cent of its nominal value. The limits in the ratio between "on" and "off" periods of the pulse are less explicit: it is customary instead to specify the extreme line conditions which can be tolerated. While the nominal value of the "off" pulse is 38½ percent of the cycle, satisfactory performance can generally be obtained between 30 to 50 percent, and in many cases somewhat beyond this range.

The permissible deviation from the nominal pulse ratio must be apportioned among the several successive stages which are required to build up a complex connection. The local switching plant of a telephone system uses so many units of apparatus that they must be produced in the most economical manner: in other words, the tolerances in their performance should be as wide as feasible. Conversely, since there is only a comparatively small number of toll circuits having access to local equipment, it is sound economy to keep distortion over the toll signaling circuit as low as possible.

A further reason why the pulse tolerance should be apportioned to the local plant as far as feasible is that most of these plants were installed long before toll dialing entered the picture, and thus have already taken up a considerable portion of the permissible pulse distortion.

Carrier toll dialing circuits are subject to distortion from several sources: (1) pulse-repeating from the outgoing trunk circuit; (2) pulsing conductor between trunk circuit and carrier terminal; (3) pulse-repeating by the pulse-transmitting relay in the carrier equipment; (4) characteristic performance and attenuation of the carrier signaling channel, and interference with it; (5) pulse-repeating by the pulse-receiving relay at the carrier terminal; (6) pulsing conductor between carrier terminal and repeater; (7) pulse-repeating by the automatic repeater.

The above causes of distortion—except (3), (4)

and (5)—are not confined to carrier systems: they are general problems in the design of relay-type pulse-repeating equipment over certain voltage, line and input ranges. With suitable adjustment and circuit design, the distortion can be kept within practically any desired limits. Actually, standard telephone-type relays are used under (1), (3) and (7), with standard adjustments and circuit arrangements. Their performance, therefore, corresponds to that of pulse-repeating circuits over physical lines.

It is obvious that the performance of carrier dialing circuits depends almost entirely on the quality of items (3), (4) and (5). Figure 2 shows the over-all signal distortion of a carrier circuit as a function of input pulse ratio, for various line attenuations, relative to their nominal value. It is apparent from the diagram that the carrier dialing circuit as a whole has a certain compensating tendency on signals already distorted at the input: pulses which were short are stretched, normal ones are reproduced with negligible distortion, and those which were long at the input are shortened.

Signaling Range

With a given sending power and channel attenuation, the performance of the signaling circuit depends on the sensitivity of the receiver and on the amount of interference. The sending power is specified to be between +2 and +6 dbm, measured at the transmitting amplifier output. The signal is amplified by the receiving amplifier to about the same level. This level is considered throughout this article as the normal operating level of the signal receiver, and the system is adjusted to this level during its initial lineup. Subsequently, there will be some variation from this normal operating level due to changes of line attenuation. Although these variations can be offset by manual or automatic gain regulators, the usefulness of the signaling system is greatly enhanced if the signal receiver responds reliably over a fairly broad range of signal levels. On a 200-mile circuit without intermediate repeater, for example, the signal receiver should perform satisfactorily between a 4-db reduction and an 8-db increase from normal line attenuation.

With reference again to the operation of the signal receiver, Figure 8 shows the amount of plate current of the relay tube over the signal input range to the receiver —0 being the normal operating level, as defined above. When a certain channel is not in use, the corresponding carrier is absent, and the relay tube is biased to about —4 volts, passing 13 milliamperes plate current through the pulse receiving relay, which is thus held operated. When the toll circuit is seized, the received carrier signal, upon being amplified and rectified, increases the bias and reduces the plate current to a value insufficient to hold the relay, which therefore restores. Plate current cutoff is at about —8 volts.

During pulsing the carrier is alternately interrupted and reintroduced. Plate current flows and

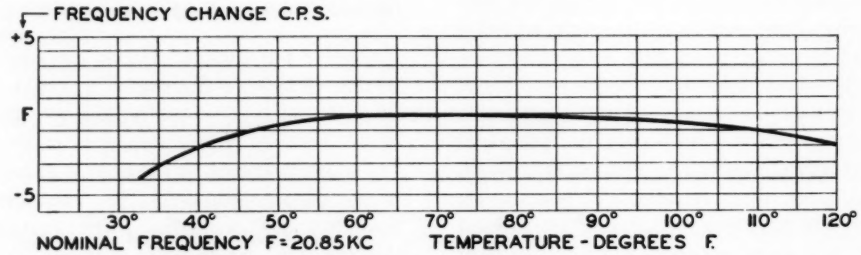


Figure 6—Oscillator Stability Characteristics.

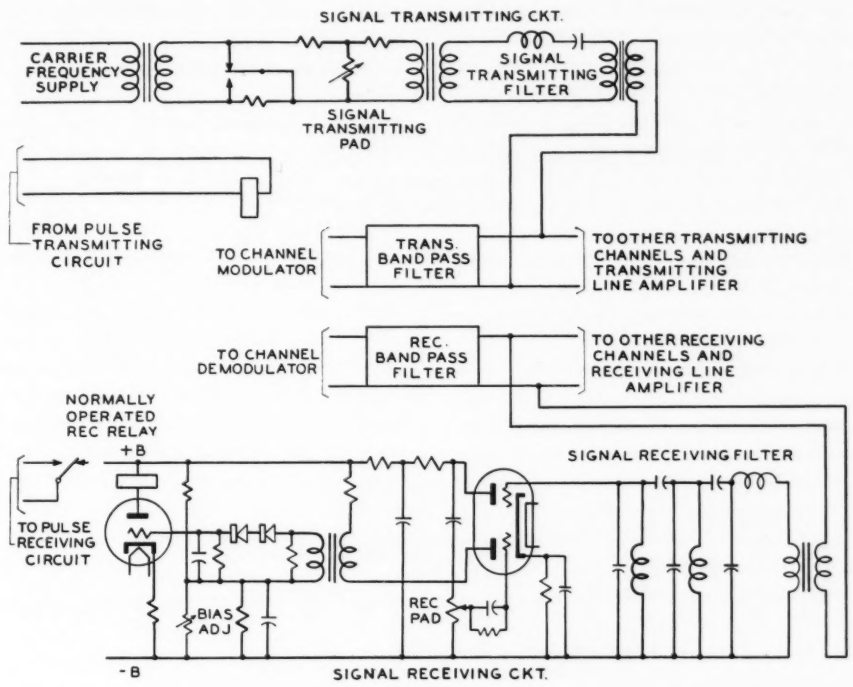


Figure 7—Signaling Circuit Diagram.

is shut off, while the receiving relay operates and releases accordingly. While carrier signal is received, d-c potential is extended through the back contact of the released pulse-receiving relay to the automatic equipment. Conversely, during interruptions of the dial and the carrier the d-c potential is removed by the operated pulse-receiving relay. Figure 8 shows the output from the back contacts of the signal receiving relay, covering the period (nominal value 38½ percent) corresponding to the closed condition of the dial. The diagram is prepared for 12 pulses per second with the standard input pulse ratio, and is representative of the over-all performance of the channel, including the signal transmitting relay. The total output pulse ratio variation over a 12-db range is about 2½ percent—only a fraction of the distortion that the automatic equipment can tolerate. The 12-db range itself is much wider than that occurring on a day-to-day basis in most practical applications.

The consistent pulsing output over such a wide variation of input level is achieved by a special circuit arrangement of the signal receiving amplifier. The latter is normally operated with current flowing in the grid circuit. However, a variable back-bias voltage, proportional to the input signal level to the receiver, is developed across a condenser-resistance combination. The output of this amplifier, therefore, remains substantially steady over a considerable variation in signal input level.

Interference

The next problem involves investigating possible sources of interference with the signaling channel. The principal ones are: (1) noise induced on the line from external sources; (2) interference caused by the associated or electrically adjacent speech channel; (3) carrier leak.

External interference is even more detrimental to signaling than to voice transmission. For-

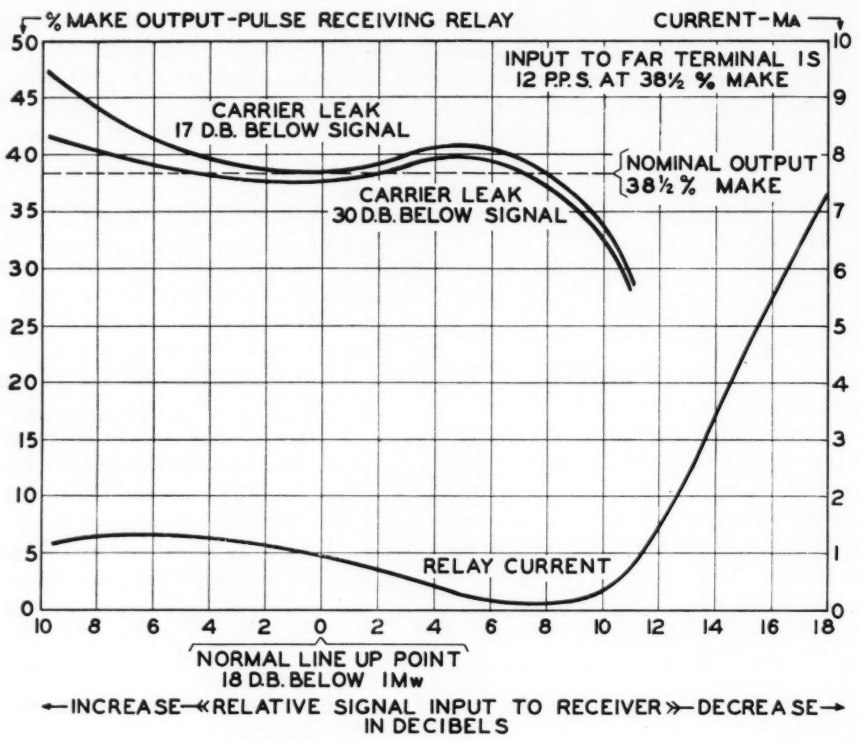

% MAKE OUTPUT-PULSE RECEIVING RELAY
CURRENT-MA
INPUT TO FAR TERMINAL IS 12 P.P.S. AT 38½ % MAKE
CARRIER LEAK 17 D.B. BELOW SIGNAL
NOMINAL OUTPUT 38½ % MAKE
CARRIER LEAK 30 D.B. BELOW SIGNAL
RELAY CURRENT
NORMAL LINE UP POINT 18 D.B. BELOW 1Mw
←INCREASE←«RELATIVE SIGNAL INPUT TO RECEIVER»→DECREASE→ IN DECIBELS

Figure 8—Signal Receiver Characteristics.

tunately, there are several methods available for controlling this interference, such as suitable transposing of wires, or, in case of severe power disturbances, shortened repeater sections. If the interference has the same frequency as the signal carrier, its effect is similar to that caused by carrier leak; if it has a frequency some distance away from that of the carrier, the effect is comparable to speech-channel interference.

Should interference cause trouble in signal transmission, there is one remedy which always works: improving the signal-to-noise ratio by raising the signal level. There are, unfortunately, certain objections to this practice. As mentioned before, the signal power is specified at 2 to 6 db above 1 milliwatt. This is considerably lower than the level at which speech is transmitted, the latter being 18 db above the audio input level at the switchboard. Such a comparison may prove misleading. While a 1-milliwatt reference level for speech is generally accepted as a convenience and reflects at least the order of magnitude of the power content of speech, the major portion of a conversation has considerably less power, because the frequencies under 200 to 250 cycles with high energy content are effectively eliminated.

Peak values of several decibels above 1 milliwatt are rare, and of comparatively short duration. On the other hand, the signal frequency is present at a constant level during conversation, and it may leak through the band-pass filter of the adjacent channel and demodulate there to a high-frequency tone—between 3200 and 3900 cycles, depending on the channel in question.

The signal frequency must therefore be limited to a safe compromise value, lest it cause interference with speech during periods of low energy

level. Inspection of the band-pass and demodulator low-pass filter characteristics reveals that the residual tone will be from 65 to 90 db below 1 milliwatt, with the specified signal transmitting level and on a 0-net-loss circuit. The value is perfectly satisfactory and barely detectable on a listening test, but it also indicates the limitation in signal power.

The second source of interference comes from the speech channels. Two must be considered: the lower frequencies of the associated voice band and the higher frequencies of the next channel. It will be recalled that the signal receiving relay is normally energized, and releases upon receipt of carrier frequency. This relay is adjusted to release when the plate current falls below 1.8 milliamperes. The plate current *vs.* signal level curve of Figure 7 shows that this value is reached when the carrier is 12 db below the nominal setting of the signal receiver, or stronger. This means that the interference must be kept below this value to maintain proper operation.

Figure 4 shows the attenuation characteristics of a signal-receiving filter. Since frequencies under 300 cycles are substantially attenuated in the audio channel, and those under 200 cycles effectively cut off, the signal filter attenuation —18 db at 200 cycles, and 28 db at 300 cycles off the carrier—is sufficient for reliable operation. There is an even greater margin against interference by the upper frequencies of the adjacent channel.

Interference may also be caused by carrier leak, which is the residual carrier frequency which passes from the voice channel modulator, through the transmitting channel band filter, onto the line. Since the carrier leak and the signal current have identical frequencies, the "leak" current will pass through the signal-receiving filter with a minimum of attenuation. If it is sufficiently strong it will cause a false signal to the switching equipment by releasing the signal-receiving relay. Although the carrier frequency is adequately suppressed, as a rule, by the balanced circuit arrangement of the modulator, imperfect balance may nevertheless permit a small amount to be present. This will be further attenuated by the transmitting band-pass filter.

As mentioned above, a maximum carrier leak of —15 dbm is specified—in other words, 17 db below signal level. It was also mentioned that the release value of the signal-receiving relay is 1.8 milliamperes, and that (see Figure 8) no signal less than 12 db below the nominal adjustment of the receiver would bring the relay current under this value. Since the carrier leak is at least 17 db below the normal signaling power, the line attenuation could drop 5 db before false operation occurs. Such a drop in attenuation is hardly permissible, because the associated four-wire-to-two-wire terminations of the voice channels would become unstable. A reduction of channel loss of such magnitude is almost impossible, and is not permitted in practice.

In this connection the efficiency of the automatic bias control in the signal-receiving amplifier can be strikingly demonstrated. Figure 8 shows that the current through the receiving relay is 1.3 milliamperes when the signal level is 5 db above that for which the nominal adjustment of the receiver was made. The same amount of relay current is also obtained for a signal power 12 db below the nominal adjustment point. Since 1.3 milliamperes is below the value at which the relay holds, it releases.

The significance of this is that with the maximum permissible carrier leak of 17 db under the signal power and the line attenuation reduced to 5 db below its normal value, the receiving relay is in its released position, regardless of whether there is a signal current present or not. On the other hand, also according to Figure 8, actual tests indicate that under the same conditions the receiving relay is pulsing satisfactorily with only 2 percent loss from the standard pulse ratio. The explanation of this apparent contradiction can be found in the time constant of the bias adjustment. The bias is always determined by the combined signal current plus carrier leak level. It is maintained at this point by the time constant of the bias circuit during subsequent short-period interruptions of the signal current, even with the carrier leak still present.

Application of Toll Dialing Systems

The link between the carrier terminal and the automatic or toll equipment is a trunk circuit or repeater. Its function is to convert the simple on-and-off conditions of d-c potential on the signal

"in" and "out" leads into the various conditions required by the associated switching equipment. Conversely, it translates the various signals used in telephone switching into these on-and-off potentials to the carrier terminals.

Four conductors are used between terminal and switching equipment. Two of them are for voice transmission and two for signaling, one in each direction. Terminal and switching equipment may be in the same location or some distance apart, since a conductor resistance of up to 300 ohms is permissible without special provisions.

There are many different types of trunk circuits and repeaters, since there are many different methods of operating telephone systems. All consist, however, of relays, retardation coils, condensers and resistors. Some of the circuits are simple, employing only three relays. Others are of varying complexity, depending on how they are used and what they have to do: the toll circuit between an automatic exchange and a toll board, discussed above, is an example.

On an incoming call, the following must take place: seizure of the local equipment; busying of the repeater against attempted outgoing calls; transference of dial pulses from the signal lead to the talking loop; return of supervision to the operator when the called subscriber answers, flashes his switchhook or disconnects; and release of the connection from the distant end. On an outgoing call to toll, on the other hand, this sequence must occur: seizure of the carrier circuit and signaling of the distant operator; return of ring-back tone to the calling subscriber; signaling of the automatic equipment when the operator answers; forwarding of identification to the operator if the call originates from a paystation (a repeat identification on challenge); forwarding of a disconnect signal when the calling subscriber hangs up; and release of the connection when both the operator and the calling subscriber disconnect.

The same general method of operation as described above can be applied to many other types of telephone traffic—such as intertoll dialing between remote toll centers, or interconnection of several automatic telephone centers by carrier dialing circuits which permit subscribers to complete connections themselves without the assistance of an operator. The problem of subscriber dialing in toll traffic has become increasingly important, and a simple carrier-dialing system contributes a great deal to its solution.

Public toll dialing, employing the normally suppressed speech carrier as a signaling channel, was first used in commercial traffic by the Interstate Telegraph Company between Bishop and Leevining, California. The dialing equipment was designed and manufactured by Automatic Electric Company of Chicago, and the carrier system by Lenkurt Electric Company of San Francisco. Several similar systems have since been placed in service.

A typical example is a Director network of several widely separated Strowger Automatic exchanges in Venezuela. All calls between offices are completed by the subscribers themselves, without the assistance of an operator. Some of the offices are interconnected by carrier dialing circuits.

In all these applications the carrier equipment and signal terminals are identical, with the trunk circuits and repeaters, custom made for the purpose, accomplishing the special functions.

Carrier dialing also solves the problem of automatic operation over radio links. Carrier telephone channels are superimposed on the radio carrier channel, and dialing or signaling is performed through the telephone carrier signaling channel exactly as described for wire communications. The first public use of automatic impulsing over radio links was when the Mutual Telephone Company of Hawaii installed Automatic Electric and Lenkurt equipment for dialing inter-island connections.